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UTILIZATION OF DEAD ANIMALS AND CONDEMNED ANIMAL OFFALS

NICLAI Series—4

UTILIZATION OF DEAD ANIMALS AND CONDEMNED ANIMAL OFFALS

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FOREWORD

The leather industry is a very unique one in that the raw material is never available to exacting specifications ideally needed for manufacture. The material (hides and skins) is not a primary product, but a by-product of the abattoir/meat industry which depends on animal husbandry and thus in turn on agriculture and rural economy. Thus, it is clear that the roots of the technology of leather production are rather adventitious, ramifying widely and go deeply into several diciplines of knowledge. Keeping pace with the rapidly developing knowledge in these diverse faculties is certainly a difficult task.

The 'National Information Centre for Leather and Allied Industries' (NICLAI), one of the sectoral centres, being developed at 'Central Leather Research Institute' (CLRI), Madras, under the 'National Information System for Science & Technology' (NISSAT) programme of the Dept. of Science & Technology, is endeavouring to bridge the gap by bringing out a series of user oriented publications. These publications, inculding monographs and other compilations, are expected to be of immense use to those engaged in diverse aspects of research, development, technology transfer, production and commerce in the field of leather and associated materials. These publications are specially oriented for practical applications.

This monograph "Utilization of Dead Animals and Condemned Animal Offals" is an attempt to spell out the 'Dos' and 'Dont's' with regard to utilization of animal wastes. The techniques described include urban and rural situations, describing potentialities both large and small scale. Quality standards and quality assessments are emphasised in the production techniques, keeping in mind the basic limitations in raw material choice for quality.

This monograph is expected to cater to the needs of a wide range of categories of persons viz., the village headman, the manager of a by-product unit or an abattoir, the renderer, the public health authorities, the veterinarians, the socialogists and the economists, each one finding something specific to look for. The importance of this publication stems from the fact that the manufacture of products from animal waste is a down-to-earth social responsibility appended with a reasonable margin of profit.

N. RAMANATHAN
Acting Director, CLRI, Madras.

PREFACE

Waste is a product of human activity. In nature, everything is a part of a continuous cycle which eventually re-enters the chain of life. Thus, the concept of utilization of dead animals and condemned animal offals stems from the efforts of man to speed up the already existing cycle of nature in a manner that refurbishes his environs and provides an economic uplift to the society. The skin, offal meat, bones, horns and hoofs are essentially the products for recovery and further processing from the dead animals. Leather, tallow, meat-cum-bone meal, hoof and horn meal, to name a few, are the final products won for utilization and profit.

Raw material quality and final product value are inseparable attributes to any manufacturing process. Oddly enough, carcass utilization punctuates the prospects for choice of raw material. This set back does not however justifiably mollify or arrest the need for carcass utilization. On the contrary, carcass utilization is an economic and social responsibility vested with reasonable financial returns.

In this manual, an attempt is made to inform how best one could utilize dead animal (carcass) and offals for beneficial end uses. Carcass being a material turned from life to non-life, is prone to have undergone the assault of death by natural gerantological route or have succembed to a disease. Thus, an assessment of the carcass for its end use namely rendering should naturally begin with an enquiry into the probable time of death, cause of death and finally dismantling the animal into components for further processing.

Dismantling a carcass for rendering is akin to a postmortem performed by a pathologist. The carcass is likely to harbour infectious agents of zoonotic and anthropozoonotic significance. A renderer who is equipped with a background knowledge of these hazards and who is meticulous about handling these materials would have done a yeomen service to society. Further, the carcass utilization centre should not become vulnerable as an endemic foci for spread of diseases. In this context, a chapter on pathology for carcass inspectors furnishes certainuse ful guide-lines. These guide-lines are all the more important in areas prevailing in developing countries where the services of veterinarian may not be readily forthcoming.

Rendering operations, deriving products therefrom and their quality evalution are the core subjects for discussion in the text. Rendering of smaller animal offals and fish offals have also been included. Emergency rendering techniques as might be needed when death of animals occur on a cataclysmic scale have been suggested. Certain aspects of energy requirements for processing have also been outlined.

Alternatives to rendering, e.g. alkali process and alternate uses for carcass material other than for rendering e.g. manufacture of Prussian blue and Twitchell process for glycerol from crude fat are discussed in order to widen the scope for carcass based products.

Every attempt has been made to minimize technical jargon, at the same time not forfeiting the utility value. A selected list of references has been provided which indicates data that lie vastly scattered beyond this compilation.

This book is expected to serve as a handy manual to any one interested in techniques and methodologies of utilization of dead animals and condemned animal offals and as an additional information source to those processing animal by-products of abattoir origin.

The author is of the firm opinion that better methods of animal management and disease control measures, when organized and implemented on a global scale, should ultimately eliminate or at least minimize the need for utilization of dead animals as animals will be purpose reared, sytematically culled and slaughter stock assigned leading to natural mortality rates becoming negligble or nil. These methods recommended will however remain applicable to condemned animals and animal offal processing made available from the abattoirs.

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CHAPTER – I

Introduction

Dead animals and condemned animal offals are refered to under the term 'carcass'. Carcass as understood for the purposes of discussion here, is the whole body of dead animals and parts of carcasses condemned or declared unfit for human consumption during ante–mortem or post-mortem inspection in an abattoir. Thus this definition excludes carcasses and parts of animals obtained from an abattoir for the purpose of consumption as food. Carcasses are also termed as fallen animals, a term that is devoid of confusion and clearly secludes dead animals from those animals killed for the purpose of food.

The discussions that follow, relate in general to the utilization of cattle carcass ; the techniques applicable to cattle, are equally applicable to carcasses and parts of smaller animals like sheep, goat and pig.

A discussion on processing offals of poultry, fish and carcasses and parts of other exotic animals not classified under livestock is also provided.

The term 'offal meal' has been used in a general sense throughout the text, to describe the meal made from any kind of animal that falls in the definition of carcass.

Why utilize carcass

Disposal of carcasses by burial or incineration is widely practised in most of the developed countries, where organized systems in animal industry preclude the need for carcass utilization. The disposal of dead animals and offals by suitable methods becomes a necessity and at times a problem in organized livestock industry and in abattoir practices. The number or quality of animal offals under these conditions far out-number the livestock dieing in wilderness. Man has constantly endeavoured to maximize the utility of products of nature, as he is complexly involved with influencing their availability and scarcity. Intensive farming, hybridizatian, artificial insemination, emendation of abattoirs are some of his attempts to increase the quality and availability of farm products to fill his victual needs. Yet another method of enhancing the resources for food supply is to minimize utilization of food products for other purposes. The utilization of edible fats, for example, for industrial end uses, or edible proteins for livestock feed supplements will be a felodese if they are already in short supply. This situation prevails to a cognizable extent in India and in most other developing countries.

The proteins, fats, minerals and many other raw materials for livestock farming and industrial uses can be made available through carcass utilization. The extent of substitution the carcass based products will provide, depends on the availability and economics of processing carcasses.

Availability of carcass and offals

To maximize economics of production, many livestock farms have systematic methods of culling their stock. Thus in such farms, annually, a minimum of 10 to 15 per cent of stock are slaughtered from farms where cattle are maintained for milk or sheep for wool. Growing animals for a specific purpose is a practice followed in most of the developed countries where animals are specifically bred and fattened for meat as much as they are for wool or milk. These practices obviously aim at minimizing mortality rates in the stocks by proper animal husbandry practices and prophylactic measures against diseases. Under such ideal conditions, the problems or conversely the prospects for carcass utilization are minimal and occasional deaths are dealt with by burial or inceneration as an economic means of disposal.

Contrary to the above ideal situation that prevails in developed countries, the livestock in developing countries are largely maintained as small holdings in the vastly scattered rural environments. The number of livestock maintained under such conditions far out-number those maintained in a few and scattered, organized livestock farms.

Although deaths in livestock due to diseases, malnutrition and ageing are least prefered to that of disposal for slaughter, the farmer with a small holding more often encounters low to heavy mortality rates in his livestock holding. It is beyond the scope, here to suggest ways and means of better farming methods and animal husbandry practices. We shall consider here the methods for economic utilization of carcasses, which to a reasonable extent alleviates the loses, until such time developments in animal husbandry will pervade to the inaccessible rural areas to teach methods of maintaining healthy livestock and economic planning of returns from them.

Mortality among livestock under depraved conditions occur due to various reasons. Malnutrition, injuries which lead to sepsis and death by septicaemia, accidents which maime livestock to which they finally succumb. deaths during transportation through long distances on hoof without feed or water, or death due to fatigue, a sweeping ravage of an infectious disease are some common causes of mortality. Mortality among calves and lambs also far exceeds those dieing after maturity. Cattle mortality rates of 70 per cent from birth to six months of age are not uncommon. Under such conditions it is usually possible to collect 10 dead animals per day within an area of 100 to 200 square kilometers. The deaths are far more under specific climatic zones which are constantly exposed to severe drought or heavy rainfall or snow. Under such circumstances the deaths are seasonal and at times far too many in number to be dealt with by a carcass utilization unit equipped to process five to ten carcasses per day. Ways and means have to be evolved to tackle such fluctuating availability of carcasses. Some methods like drying and alkali processing are described in chapter 10 and 12 to meet such vicissitudes. (See also appendix VI)

Economics of carcass utilization

The economics should be worked out on the assumption that a minimum number of five carcasses or a ton of offal material will be available per day. Location of dead animals, their transportation to the centre, expended costs in securing and transportation, cost of setting up a unit (capital costs) energy and man power requirements and their availability (recurring costs) and marketing prospects for commodities produced are aspects that primarily control the economics.

Location of dead animals

Carcass rendering plants are either set up as common facility centres by farmer cooperatives, public sector or social welfare organizations or by private entrepreneurs. In any case, once the stock owners realise that their dead stock provides some returns far more than that obtainable for skin alone, he will be willing either to transport the dead animal to the centre or offer the dead animals to be collected by the operator. In either case, the location or identification of the dead animal and its value in terms of money is usually struck by bargain. The value is based on the distance to be transported and the condition of the carcass. Certain guidelines for the assessment of carcass are given in chapter 2.

Transportation

Transportation is the prime limiting factor and at times an obstacle that averts the economic processing. Transportation by the cheapest means should be planned as it is wellnigh impossible to collect all the carcasses for a day's requirement in one trip. Farm carts or hand drawn carts are the most commonly used means of transportation under rural conditions (Fig. 1). The carcass centre could own such carts for this specific purpose.

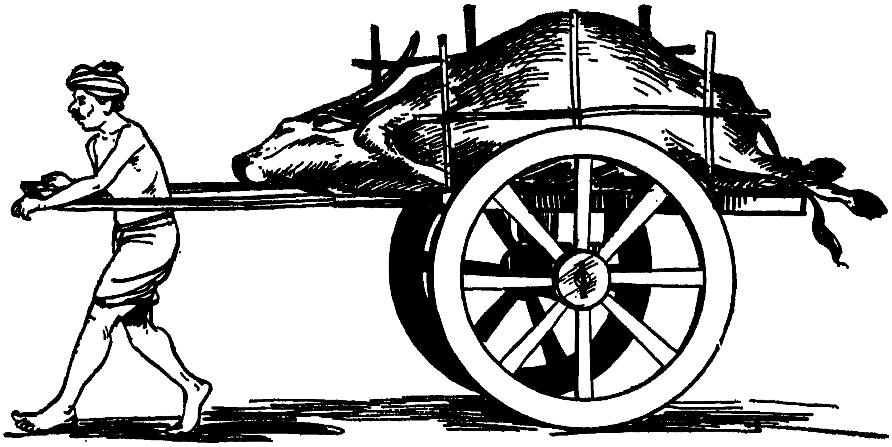

Fig. 1 : Farm carts are commonly used for transportation of dead animals in rural areas

COST OF A UNIT FOR RENDERING

Major costs in setting up a unit for carcass utilization are expended on a rendering unit. Rendering can be broadly understood as a process used for the preparation of offal meal after separation of fat from dead animal materials or condemned offal materials. The cost of rendering unit is dependent on the choice of the type of process envisaged. The rendering processes largely fall under the following categories:

(i) Open kettle rendering,
(ii) Wet rendering,
(iii) Dry rendering, and
(iv) Other rendering methods.

The different processes are described in detail in chapter 7.

Open kettle rendering

Open kettle rendering is extensively practised in rural areas and small farms. The advantage of this method is that the capital costs involved are low. But this is largely offset by the fact that the energy (heat) expended is far from being economical. The net energy required due to uncontrolled heat loss is far higher under these conditions of operation. The only way energy expended could be made economical is by resorting to locally available cheap fuels. It is worthwhile to note here that fuels are not any way cheaper under rural conditions as they are under urban conditions in most parts of India today.

Wet rendering

Wet rendering is the method of choice for production of edible tallow from abattoir offals passed as fit for human consumption. The quality of tallow obtainable is superior. By wet rendering, however, the loss of soluble proteins and the yield of offal meals obtainable is lower.

Wet rendering process, which is essentially an emended open kettle rendering, lends itself for erection and operation under rural conditions. This is so because the level of technology needed is less than that for dry rendering.

Dry rendering

Dry rendering can be considered as the industrial process for handling offal products, where the energy requirements are most optimally operated. In this process, the heat supplied evaporates the residual moisture present in offal materials. The offals cook and disintegrate under such conditions and a semi-dry offal meal and tallow are obtained. Dry rendering is thus prefered for inedible offal products (fallen animals for example) where flavour, odour and quality of fats are secondary and the production of a large quantity of high quality residue (offal meal) is important.

Other rendering methods

Lowry circulating rendering, Kingham continuous rendering, Chayen 'Impulse' rendering, vio-bin azeotropic rendering, dry melter-steam tube dryer process, centrifugal rendering, enzyme rendering, alkali/acid rendering are some of the other render ing methods applicable as general methods for recovery of fats and oils and also applicable to offal meal processing. Chemical additives to offals and fats minimize oxidative changes and thus greatly assist in the recovery of fats of better quality by rendering. Details of these methods of rendering are given in chapters 7 and 8.

CHAPTER—II

General Assessment of Carcass for Rendering

Dead animals are usually not available immediately after death for processing and therfore will undergo varying degrees of putrefaction depending on the interval between the time of death and inspection. Highly putrefied animals are unsuitable for processing into carcass end products and the methods for their disposal are discussed in chapter 10. Inspection is a prerequisite to identify the cause of death. For example, animals that have died of an infectious disease like anthrax are *NOT* to be flayed for recovery of skin. Flaying of such animals that have died of infectious diseases will cause the spread of disease to healthy animals in the neighbourhood. Similarly animals that have died of acute poisoning, arsenic for instance, when processed into offal meal will be unfit for use in animal feed. From the above examples, it is clear that inspection of the dead animals is a must and should be performed with care by trained personnel.

Inspection personnel

Veterinarians have the highest level of training and authority to decide the suitability of a carcass for its ultimate end use. However obtaining the services of veterinary personnel under field conditions, especially when the number of carcasses processed are few may not be feasible. Livestock inspectors or other personnel who have obtained a basic knowledge in biology can be trained to undertake a preliminary inspection and certify the carcass. In such cases, inspection by more than one trained person will be an advantage. In case of any suspicion on the suitability of the carcass for a particular end use, services of a veterinarian should be obtained for his verdict.

Oral enquiry

When a carcass is brought to the processing centre, or when collected from the field, proper enquiries must be made to collect all possible reliable information. The ownership of the animal should be ascertained and recorded. Probable time of death and cause of death as defined by the animal owner are important data. One should also find out if death of animals in the area or his herd due to similar causes or similarly described symptoms prior to death, has been a common occurrence. This will help to ascertain the prevalence or not of any infectious disease or an endemic. If the animal collected has been lying since death on one side, that side should be noted. This side of the carcass will be found to be usually darker than the rest of the carcass during post-mortem examination.

Immediate cash settlements for the purchase of the carcass are best, but may not be practical for carcasses purchased especially from underdeveloped districts. An experienced renderer should have no difficulty in assessing the worth of the dead animal on visual inspection. Some of the factors for assessment are: probable cause of death; time interval between death and procurement, size and age of the animal; condition of skin; and distance to be transported from place of death to processing unit.

Probable cause of death

The inspection personnel must make a preliminary examination of the animal and correlate the information obtained by oral enquiry. Oral enquiries could be at times misleading and should be assessed with caution. The need for cash, might at times, force the owner to foist unreliable information. Animals that are suspected to have succumbed to infectious diseases, endemic or otherwise in that area, most of which are notifiable diseases under the law, should be dealt with as discussed in chapter 5

Time interval between death and procurement

The shorter the time interval between death and processing the better. With lapse of time, putrefactive changes set in rapidly especially under warm and tropical climates; such changes are aggravated by humid weather. Thus the time elapsed is an important criterion and animals that have undergone extensive putrefactive changes, usually obvious by the foul odour, are unsuitable for processing. Disposal of such animals is similar to that followed for animals that died of infection.

Size and age of the animal

There is no doubt that larger animals will yield more offal meal and tallow than smaller ones. The age of the animal at death may not be relevant but can be assessed for record by checking the teeth. Aged or senile animals yield very little tallow and the skin is usually poor in substance. Well developed horns in older animals may be marketable for a good price.

Condition of skin

The skin of a dead animal, particularly skins of bovines, fetch the highest value compared to other parts of the animal. The skin could be damaged after death, or possess defects acquired during the life span of the animal. Dead animals that have been left unattended during day, will be pecked by carrion birds (Fig 2)

Fig. 2 : Vultures pecking at neglected carcass in the field

and crow and these could cause punctures, sniks and tears on the skin. Carrion animals may have even eaten or removed sizeable areas of skin and meat of dead animals. Putrefaction on the side of the skin on which the animal has been resting since death is also more rapid.

Distance to be transported

As stated earlier, the animals could have been brought by the owner to the processing unit or should have to be transported from the field. In either case, the expense of transportation does add to the cost of the carcass. The cost of transportation could be a single limiting factor deciding the success or failure of the project. It should also be noted that cheaper means of transportation through long distances also adds to the time lag between time of death and processing, thus resulting in a putrid raw material than that originally located.

CHAPTER—III

External Inspection of Carcass

Death and Ensuing Changes

The process of death of an animal and the changes that ensue (post-mortem changes) provide important information to the personnel engaged in carcass utilization. The cause of death and the time elapsed between death and processing can be better understood if one obtains a basic understanding of the process of death. This process and the changes thereof, as they occur when an animal dies is what is piously termed as natural death, are described in this chapter. This applies in general to animals dieing due to other causes such as an accident, disease or other reasons such as starvation, drought, malnutrition and fatigue.

Mechanisms of death

When natural death ensues the animal usually dies due to failure of the heart to function. The animal which has already become senile, malnourished and weak becomes unable to support the requirements of the heart to continue functioning. The failure of the heart is progressive and its musculature which is already short of oxygen and energy providing nutrients, particularly glycogen, relaxes and becomes flaby. Thus the heart comes to a standstill, circulation of blood ceases and the lung is no more capable of transporting oxygen through blood by circulation. The oxygen want and failure of removal of metabolites from the various parts of the body leads to an arrest in the activity of all the systems and organs in the body. The animal would struggle and finally ceases to breathe much earlier or in course of time. The animal is now dead due to the failure of heart.

Rigor mortis

Glycogen is the constituent that provides the animal energy for muscular movements during life. When alive, as the animal exercises, the glycogen is converted into lactic acid (sarcolactic acid) by a complex energy gain pathway. In life, lactic acid is constantly removed by circulation and replenished with glycogen, thus maintaining the equilibrium of the functioning system. When death ensues, lactic acid accumulates in the musculature. Added to this, the contracture of the musculature caused by the conversion of glycogen to lactic acid also generates heat which cannot be dissipated by circulation of blood after death. The accumulation of latic acid and carbon dioxide, the generation of heat and several other undefinable factors cumulatively lead to the state of rigor mortis of the musculature. Rigor mortis usaually sets in within 8 to 12 hours after death and results in the carcass becoming stiff and inflexible. The onset of rigor mortis will be hastened or delayed by several factors. It is hastened by an excessive ambient temperature, or in animals that have accumulated or stored more glycogen in muscles by resting. Rigor mortis may be delayed by cooler ambient temperatures, in highly emaciated animals and in animals that have been heavily exercised prior to death, for example, when they are hunted. A clear concept of rigor mortis and its mechanisms are yet to be evolved, and an in-depth knowledge of its mechanisms is of importance in carcass evaluation of slaughtered animals in an abattoir.

Cell deterioration

One of the important attributes of a living cell (a myriad of which accumulate in an organised way to form an animal) is its selective permeability to ions and molecules of varied sizes. Once the cells are dead this selective permeability is lost. This results in random migration of various coustituents in and out of the dead cells. During life, the cell function depends largely on enzyme activity and the proteolytic enzymes present play a significant role in effecting post-mortem changes, During life, the cells do not fall prey to their secreted enzyme activity due to a complex biochemical mechanism. These having come to a cessation due to death , the proteolytic enzymes are free to act in a random manner causing rapid dissolution (digestion and lysis) of the proteins, including those of the musculature.

A freshly killed or just dead animal is flexible, with movement of joints by a handler being possible without much effort. The onset of rigor mortis causes total stiffening of the animal as described earlier. The rigor mortis passes off as proteolytic enzymes come to play and their effect becomes observable, by carcass again becoming flexible, usually 20-24 hours after death. Thus an animal that is dead for more than 18–24 hours may be again flabby, flexing easily at joints as an animal just dead. However, many other observable changes that take place with lapse of time provide clues to estimate the probable time elapsed after death.

Visible mucous membrance

It was stated earlier that the life process largely depends on selective permeability of cell membranes. This property being absent, the visible mucous membranes appear cyanotic (no longer pink as in life) due initially to the presence of unoxygenated blood in the embedded capillaries. Later the membranes turn even darker due to liberation of permanently oxidized haemoglobin (a blood pigment) which is either dark red or black. Thus an examination of the mucous membranes of the eye, the lips and the tongue, the base of the tail and udders may give some indication of the probable time of death. These are initially pale blue immediately after death (cyanotic) and then turn darker as time advances.

Exudations

The fluids of the body being no more retained, ooze out from natural openings of the body and most abundantly from the mouth, nostrils and the anus. These exudates are initially straw yellow in colour and then turn dark brown as time advances and also become more and more viscous with the passage of time.

Bloating

The bacterial population in the large intestine is usually large and during life they assist digestion by their symbitoic association. The gases produced in that process during life are expelled through anus by the peristalitic movement of the large intestine or moves forward to be expelled by belching. In a carcass, the gases simply accumulate in all regions of the alimentary tract leading to bloating. The bloated animal (Fig. 3) is tense to feel in the entrie abdominal area and with sufficient lapse of time, the tension is high enough to sound like a drum on percussion. The bodies of birds do not bloat, as accumulated gases pass through the intestinal wall into the abdominal air sacks and thence pass out through the trachea to the nostrils. Domestic poultry do not seem to carry any fermenting organisms in their alimentary canal and so they also do not bloat.

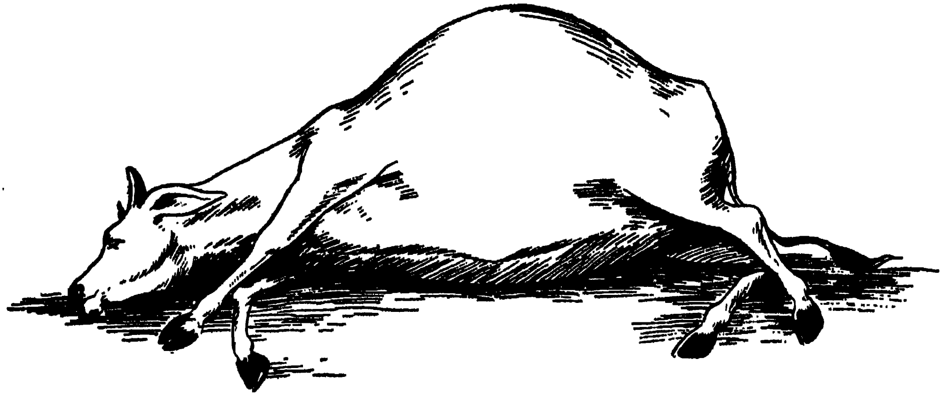

Fig. 3 : The bloated belly is a clue to assess the time of death.

The changes described thus far can be observed as external changes that occur after the death and with lapse of time (Fig. 4). Certain characteristic external appearance that differ in case of animals that have died of specific diseases, pertinent to the subject of carcass utilization are discussed in chaper 5.

LONG RANGE CHANGES

Neglected carcasses in humid environment

Dead animals that have been left to nature undergo changes depending on the immediate environment around the carcass. An animal that has been lying in moist ground will absorb sufficient amount of moisture through skin and putrefaction of skin and the carcass proceeds very rapidly. The putrefactive changes caused by bacterial action and insects that live on dead flesh (see chapter 5) can act so rapidly that merely a pile of bones may be left within a short time of 20 to 30 days. All the soft tissues would have been liquified and lost to the soil or washed away by this time. Similar changes may be expected in rainy seasons or in locations where the relative humidity is very high. These changes are not greatly altered by normal temperature fluctuations and can continue even when ambient temperatures are as low as 15°C. The heat generated by bacterical putrefaction and the thermal insulation provided by putrefied tissues enable the changes to proceed unimpeded.

Dry environment

Animals that have died and left unattended in dry climates or in hot zones as encountered in desert regions, usually dry out fast enough to such levels that putrefactive changes are greatly impeded. Under such circumstances, skin dries into a hard shell and all the musculature and contents dry up. The carcass would have completely dried in two to three months time. The carcasses feel leathery and finally stone hard, crumpling to pieces in due course of time. Camel carcasses in arid regions usually undergo such changes. This process of drying out without putrefaction is similar to the preparation of dried meat—'biltong' (Pemmican, Jerked meat) by some tribal populations. Ostrich meat from southern African countries is available for consumption as meat in that condition.*

Acidic soils

Carcass found in highly acid soils and bogs undergo a peculiar hydrolytic change, combined with changes caused by bacterial putrefaction and appear

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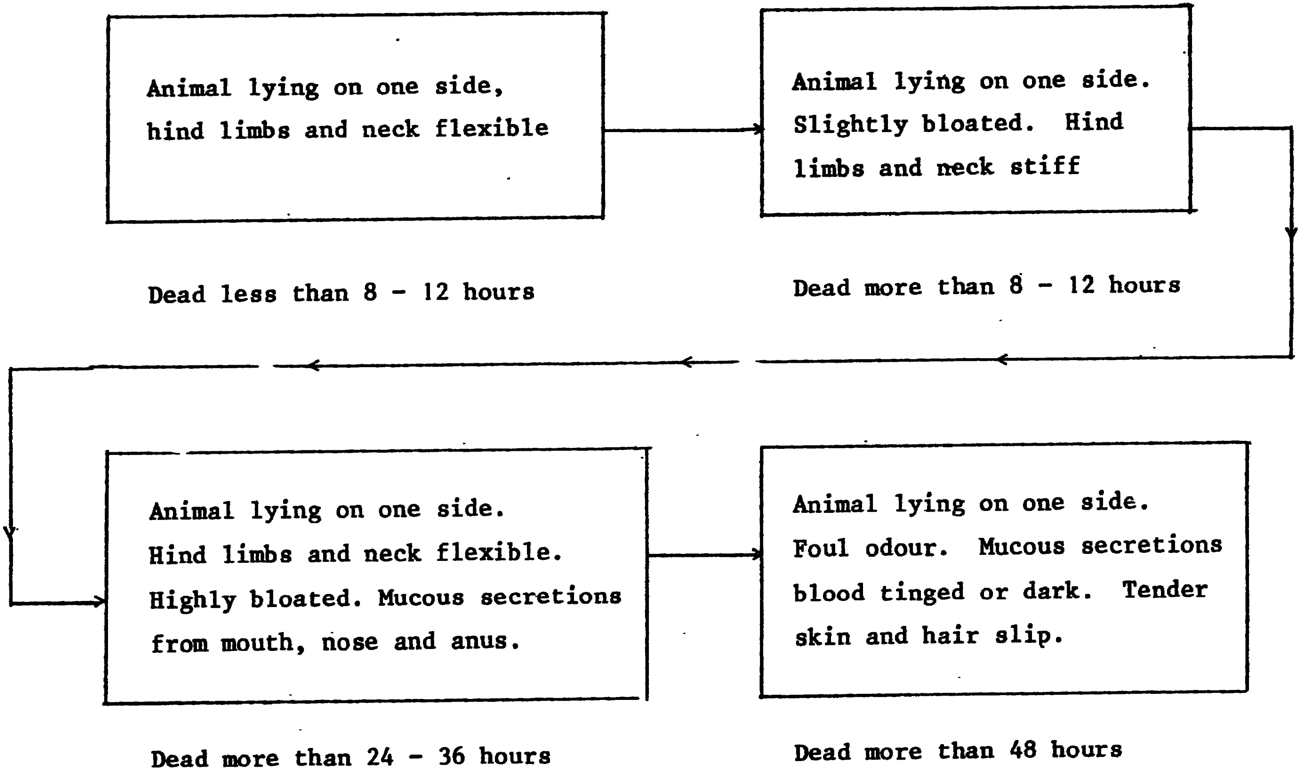
*(Vet. Bull. 1976, 46 (10 Oct. 1976, Abst. No. 6318, Schlachten and Vermarkten (1976) 76 (6) 198–201).



Animal lying on one side, hind limbs and neck flexible

Dead less than 8 - 12 hours

Animal lying on one side. Slightly bloated. Hind limbs and neck stiff

Dead more than 8 - 12 hours

Animal lying on one side. Hind limbs and neck flexible. Highly bloated. Mucous secretions from mouth, nose and anus.

Dead more than 24 - 36 hours

Animal lying on one side. Foul odour. Mucous secretions blood tinged or dark. Tender skin and hair slip.

Dead more than 48 hours

Figure 4. Post-mortem changes that take place in an animal in a warm tropical climate on a sunny day.

in the end as a bag of bones, with little visible change in external appearance. The bones may be intact and in place. This type of change takes anything from 4-8 months or even longer.

Under snow

It might be interesting to mention here that dead animals buried under snow and ice usually appear well preserved. Contrary to this normal belief, putrefactive changes do take place from intestinal organisms from inside to the outside although at a much slower rate. Ice is a good insulator of heat and thus sometimes putrefaction may even be faster, and only skin in the nearest vicinity to ice may appear normal. Putrefaction under such environment is generally anaerobic and gas production may be marked. Such animals when recovered early may not yield a good skin as formation of ice crystals disrupt the normal architecture, the ice crystals acting as sharp ended blades and needles. The water content of these skins is large and skins feel plumpy.

Boreal environment

Occasionally animals alive or dead might have been shell frozen by sudden exposure to temperatures as low as – 40°C as might occur in the arctic regions. Such carcasses are usually in a very good state of preservation with all organs intact and not having undergone any noticeable organic changes. However, even when such animals are thawed, the formation of ice crystals during thawing causes extensive damage to their architecture. Recovery of such animals intact usually for research, calls for complex technology.

Small animals

The fate of carcasses of small animals is decided by a different natural agency. Any one, who has had the opportunity to live in the vicinity of a forest would have made a surprising observation—one seldom encounters the carcasses of small animals, birds, rats or mice. It may be presumed that these have been eaten by carrion eaters and this is one possibility. The main reason for the absence of these carcasses is that a large family of carrion beetles commonly termed as burial beetles take great pains to bury the carcass. These beetles, usually in pairs, reach the carcass and the male does the work of digging and excavation under the carcass, thus burying it. It is largely due to the activity of these insect beetles that carcasses of small animas are rarely encountered in nature.

Collection of bones from neglected carcasses

It is a customary practice in many rural areas to just abandon carcasses in places far away from dwellings after flaying the skin off or at times even with-

CHAPTER—IV

Post - Mortem Inspection

Having obtained sufficient information on the suitability of carcass for utilization, one proceeds to dismantling the carcass. This procedure provides an opportunity to perform the much desired post - mortem inspection. The changes observed during post-mortem furnish sufficient information to re-assess the suitability of the carcass for various end uses.

The skin

Unlike in routine post-mortem inspection in a veterinary pathology clinic, where the value of the skin may not be realized or recognized, in post-mortem for carcass utilization, the skin is most often the highest price earner. The skin is flayed, taking every care to prevent flay cuts. The techniques of flaying are not discussed here, as expertise for flaying is usually locally available.*

Manual flaying is most ideally suited for flaying a small number of carcasses. Flaying aids such as pneumatic flaying knives may come in handy when the number of animals flayed is large. However, hide pullers and inflation of air under skin used to flay hides in an abattoir are unsuitable for flaying of carcasses. The two last mentioned devices do not generally help obtain quality hides from carcasses, especially if the time interval between death and flaying is large. This is so because the skin does not undergo uniform deterioration. The side on which the animal has been lying, for example, on a moist ground would have degraded more. Thus if automatic flaying devices are used, the damage to the quality of hide might vary from geometric distortion to irregular flaying or tearing. This only goes to show that a greater amount of personal care and attention is needed in carcass flaying and manual flaying or at best use of flaying aids is most ideal.

The flaying is partly performed on the ground and then the animal is hoisted on its hind legs to a convenient height to complete the removal of hide.

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*Those interested in obtaining information of flaying techniques may refer to the publication *Flaying and Curing of hides and skins as a Rural Industry*, FAO Agricultural Development Paper No 49. References on flaying and curing are also cited under references at the end of the text

The flaying of the skin of a dead animal offers a different feel to an experienced flayer used to flaying slaughtered beast. The warmth of the skin and body are absent. The skin of a dead animal is cold and adheres more firmly to the flesh. In slaughtered animals, the skin would be greatly depleted of its blood supply and thus the flesh side of the skin appears pale or even white. Veininess except as an abnormality is seldom observed in slaughtered hides. The dead animal hide is usually pale blue to dark brown in colour on the flesh side and the presence of cutaneous veins gorged with coloured fluid is not uncommon. The clotted blood in the sub-cutaneous region would have separated into a straw yellow to dark liquid and accumulates as droplets on the flesh side, which readily wet and spread. A slaughtered hide on the contrary will repel sprinkled water for some time.

Biological defects such as deep seated injuries and scars acquired during life and brand marks will be obviously visible on the flesh side. In slaughtered hides certain ectoparasites as ticks may still be seen (Table 2, chapter 5), but these are hardly seen in fallen hides. The ectoparasites promptly depart from the animal, as soon as the skin temperature falls, and thus are not found on these hides, even if these animals have been heavily infested during life with ticks.

Opening the carcass

The carcass is opened on the belly by making an incision from the inguinal region (region between thighs) downwards as is practiced in slaughtered stock. With the animal hanging upside down, the viscera easily detaches and drops off on the ground, but for a few membranous attachments inside the carcass. Care should be taken to insert the knife with the pointed end outwards so as not to cut or nick the tense rumen. If the rumen skin is cut or damaged, the contents very easily spill into the visceral cavity and spoil the carcass quality. At times accumulated gases may be so large in volume and stored under pressure, that the rumen bursts open on receiving a nick, throwing up the contents everywhere and on the personnel working on the carcass. Thus every care is needed to prevent damage to any part of the alimentary system. It is advisable to tie up the oesophagus end with a chord and then effect the detachment of the viscera. Similarly, several knots may be put at points along the intestine, wherever it is found that it might spill the contents. The viscera can be collected directly into a wheel barrow kept under the carcass or collected on a sheet of polythene or hesian bag and pulled away from the hanging carcass.

The same procedure is followed when carcasses lying on the floor without being hoisted are opened. It is good practice to hoist and every effort should be made to provide this facility. A casurina or a bamboo post tripod is not hard to fabricate and either a pulley similar to the ones used for drawing water from a well or a loop of rope equally serves the purpose well to hoist the animal with a rope (Fig. 5).

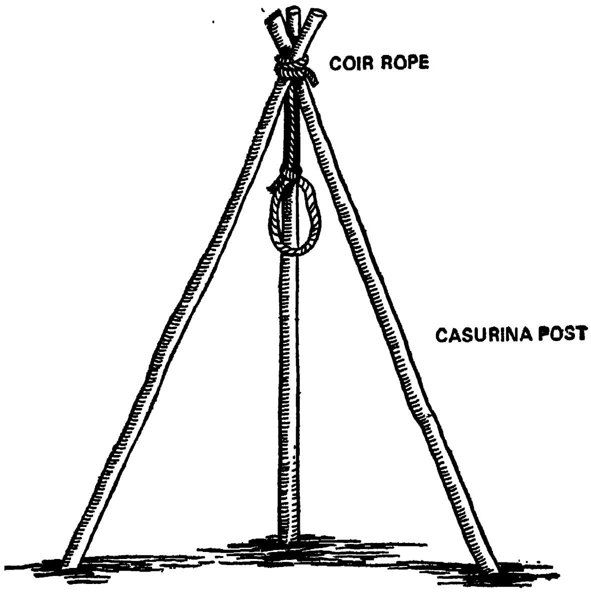

Fig. 5 : An improvised tripod to hoist carcasses

EXAMINATION OF THE DIGESTIVE SYSTEM

Rumen

The rumen is usually never empty even in animals that have died of starvation. In such animals fhe contents may reveal several strange objects not usually injested; such as hard roots, pieces of wood, paper rags and even large amount of mud, sand and any article that the animal is capable of swallowing but not digesting. Materials such as oil soaked cotton waste, iron turnings, nuts and bolts have been found to constitute a large part of injesta in certain ruminants dieing of starvation near a factory or in the vicinity of railway tracts.

The skin of the rumen and intestine appear dark green or even black. The pigmentation is caused by chlorophil of plant materials injested and hemoglobin. Near the region of the liver the bile from the gall bladder diffuses on to the surface of the liver and stomachs causing a dark green tinge. The entire skin of digestive system will weaken and finally become ruptured as the interval between the time of death and post-mortem is prolonged. The digestive system will lose its total membranous integrity within 36-48 hours after the death of the animal.

Ailmentary canal

The mucous membrane of the alimentary canal, after death, does not selectively hold the secreted enzymes from acting on itself. This allows the membranes to undergo autodigestion. Consequently the fermented pieces contained in the alimentary tract pervade every part of the body cavity and taint the inner walls of the abdominal cavity as well. These taints initially appear dark green and turn dark brown or black in colour with advancing time. This change contributes further to the fragility of the walls of the alimentary canal.

Liver and lymph nodes

It is worthwhile at this stage to examine the liver and the lymph nodes adjoining the digestive tract. The lymph nodes normally are hard in texture and if cut open (it is better not to cut open these nodes) may reveal pus like material if the animal has contracted tuberculosis during life. Bovine tuberculosis is not generally communicable to man, but care must be taken in such cases, not to spread the germs from the site of infection. It is best to disinfect the implements using lysol, meta-cresol or formaldehyde solution. In the absence of chemical disinfectants the implements are best sterilized by heating over a flame. The infected lymph nodes *if cut open or handled* must be collected in disinfectant solution or assembled and burnt.

Although rendering these infected nodes along with the carcass will destroy all organisms and make the material innocuous, the above instructions should have to be followed if lymph nodes containing pus are cut by accident or with intention. This is important because the several handling operations before the material ultimately reaches the renderer, leaves much doubt about the prospects of preventing or avoiding contamination through infected implements and personnel.

Greater care is needed with dairy cows, which are likely to carry human tuberculosis organisms. As such transmission of tuberculosis through these animal carcasses cannot be ruled out, the infected lymph nodes if cut open are best destroyed by burning or disinfection, rather than carrying them on to the stage of rendering.

It is for this reason that the knife must be used with extreme care, so as not to nick or cut open any part that need not be separated or handled.

The liver and the inner surface of the alimentary tract will provide information on the presence of any parasitic infestation in the area from where the carcass was received. This may not be of any significance, nor does it provide a possibility of their transmission to other animals (chapter 5). The data on such infestations if noted and identified will be a useful record to the veterinary health authorities for determining epizootology of such infestations. For example, the trematode *Paramphistomum* studs the wall of the rumen with large number of pomogrannete like nodules. These may be detached or even found mixed with ruminal contents. Their presence is of no direct significance to a renderer.

Heart and lung

On opening the body, it is found that the major blood vessels, particularly the arteries are empty. The veins on the side of the animal on which it was resting are filled with blood clots and that side therefore is darker in appearance. The heart if opened (it is not necesary to open) is found filled with a clot that appears to have a yellow liquid serum and a dark yellow fibrin mass with a cap of red cell clot. This happens in the heart as the blood separates sooner into its components even before clotting of blood ensues after death. Such a clot in the heart is usually termed as the 'Agony clot'. This term however does not seem to be related in any way to the agony the animal underwent prior to death.

The outer surface of the lungs are dark, filled with blood clots and particularly darker on the side on which the dead animal rested.

Musculature

It was mentioned in chapter 2 that the putrefactive bacteria from intestines multiply and pervade every nook and corner of the body. In addition, they also produce foul smelling gases. The large blood vessels that supply the hind legs are nearest to the intestine and therefore the putrefactive bacteria and the gases produced find an easy access to the musculature of the hind legs. These consequently putrify much sooner than any other musculature in the body. The location from where the maximum amount of meat is recoverable is also unfortunately the one to decay first, which is just an unfortunate augury of nature. The invaded bacteria also disrupt and ferment the blood clots thereby causing greenish taint in these muscles. The gases are also easily absorbed and putrefactive odour appears earliest in the musculature of hind legs. This is of very great significance to meat inspectors and no doubt a noteworthy aspect for a renderer as fat in this region would turn bad sooner.

The putrefactive changes and appearances described thus far can be taken as a reasonable guide in assessing the time of death (Fig. 4). These changes being a part of biological activity cannot be assessed with a stipulated periodicity or precision to obtain, for example, an hour to hour analysis. The data may well reasonably enable one to time the death into periods of interval as 6-12 hours, 12-18 hours, 18-24 hours, 24–36 hours or longer. As stated earlier, external influences such as weather and immediate environment around the dead animal also shift the post-mortem changes in either direction.

CHAPTER—V

Introductory Pathology for Carcass Inspectors

It might be intriguing to one, at the outset, whether carcass utilization technology, should really indulge in complexities of Latin terminologies of pathology, or go ahead with the assigned job. There is no second opinion to the fact that a qualified veterinarian is most suited for conducting the inspection of a carcass and assign its suitability for rendering. Secondly, he will be able to define the measures of hygiene and conduct, required in the shed where the carcasses are dismantled prior to rendering. It is also obvious that dead animals are not and cannot be directly dumped (without any handling) into the rendering plant, but go through a process akin to those in an abattoir–the animals are flayed, aviscerated and chosen components go to make the rendering stock. In earlier chapters (chapters 3 and 4) techniques for a preliminary examination of carcasses were explained, with a view to assess the quality of raw material and end product there form.

In this chapter, we set forth to understand the rudiments of pathology, a basic knowledge of which will go a long way in setting standards for public health and social welfare which are eventually the pivotal objectives of the human society.

'Traditionally' veterinary medicine is responsible for the protection of human life against those hazards which result from (a) contact with diseased animals, (b) consumption of tissues or products of diseased animals and (c) consumption of products contaminated during processing and delivery of such foods to the consumer. These functions are of basic importance in the public health programme. (Veterinary Public Health, James H. Steele, p. 329-383, in Advances in Veterinary Science, Ed. C.A. Brandly and E.L. Jungherr. Vol. 1. 1953. Academic Press. New York).

To the above statement it might be added in this context, that processes leading to the rendering of carcasses, should not result in spreading of diseases, either to animals or to man inadvertently or through ignorance. There is no doubt therefore, that a basic knowledge of animal diseases, pertinent to carcass utilization procedures will go a long way in avoiding conditions that lead to violation of public health and animal health oriented programmes.

A selected list of diseases that a carcass inspector may observe, many of which are notifiable, are given in Table 1. Notifiable diseases by definition are those diseases which are either proven to be or likely to be infectious or contagious to other livestock or man in the absence of suitable preventive measures. It is mandatory on the part of the inspector to intimate to the veterinary public health authorities and also deal with such carcasses in a specific manner (detailed below) so as not to create an epidemic foci for the spread of the disease and to seek veterinary assistance. In many countries failure to comply with these regulations is punishable.

TABLE 1

List of notifiable diseases

1. Rinder pest
2. Haemorrhagic sepicaemia
3. Black quarter
4. Foot and mouth
5. Anthrax
6. Surra/Equina/Bovina
7. Ranikhet disease (in poultry)
8. Sheep and goat pox
9. Fowl pox (in poultry)
10. Contagious caprine pluropneumonia
11. Enero toxaemia
12. Swine fever
13. Rabies
14. Contagious bovine pluropneumonia
15. Tuberculosis
16. Johnes disease
17. Glanders and farcy
18. Epizootic lymphangitis

From what has been discussed above there is no doubt that a preliminary knowledge of communicable diseases is of immense importance here.

Pathology

Pathology (from Latin Pathos—disease, Logos—science) is the science of study of diseases. Pathology encompases the study of lesions, the effects produced by a disease, which are different from the normal appearance (both macroscopic and microscopic) of component parts of the animal. These effects would be produced on the animal, by any agency from injury, insect bite, parasitic, protozoan, bacterial and virus infections and also by any changes induced by injury, nutritional deficiencies and other non-definable causes. These changes could be manifest on the skin, or found deep seated in organs or at times not recognizable by gross examination. A brand mark, for example, is a lesion produced on the skin by injury, is a permanent scar. A tuberculous lesion in the lung is a deep seated one, normally identifiable by the presence of pus like material enclosed in nodules. An animal that has died of acute poisoning as after injestion of leaves of a poisonous plant may not reveal any gross pathological changes. But on certain occasions, for example, in vicious killing of animals by arsenic trioxide, the musculature will appear brick-red in colour and the carcass remains in a good state of preservation even many hours after death. Thus in looking for pathological changes it is hard to apply any rule of the thumb and only a close scrutiny may bring to light certain pathological changes of significance.

General appearance

Certain visual clues to judge the carcass, namely exudates from natural orfices, bloat, etc., have been described in chapter 3 in the context of assessment of probable time of death. It is not difficult to judge the difference between a well fed animal and an emaciated one. An animal that has suffered a prolonged illness obviously will be emaciated and must have been lying on the ground (invariably hard and dirty) for a long time. The carcasses of such animals reveal visible bed sores. Some of these sores could even be fly blown and the maggots of flies may be found teeming in the area.

FLY BLOWN WOUNDS

Maggots (larval forms) of certain flies of the species *Calliphora* (blue bottle flies), *Lucilia* (green bottle flies) and *Sarcophaga* (flesh flies) are found in the vicinity of carcasses. Blue bottles are most commonly found feeding on dead flesh. The other two flies infect wounds and produce a condition termed myasis. The maggots of these flies will be found infesting bed sores and other open wounds on the animal.

These wounds drastically undermine the value of skins. When these maggots are found in a carcass it is best to collect and destroy them by throwing them in a pit with lime, or no harm is done by including them with the rendering stock. Leaving them alive will aid in propagating these flies and therefore is not advisable.

WARBLES

Warbles appear as nodules on either side of the back, fairly widespread on the skin (Fig 6). Warble nodules are a stage in the life cycle of the warble fly *Hypoderma*. The adult flies lay eggs on the heel of animals. The eggs hatch and the larvae penetrate into the skin, travel through a complex migratory cycle to reach the skin of the back. The warbles that come out of these nodules become adult flies after passing through the pupal stage in the ground. The warbles immensely reduce the value of skin, by perforating the most valuable areas on it. The warable nodules must therefore be destroyed, as otherwise they will repeat the menacing life cycle, much to the detriment of animal industry.

OTHER SKIN CONDITIONS

Mange, more commonly, in sheep and goats, demodectic mange in goats and cattle, and sometimes ticks are often encountered on the skins of animals. A carcass inspector can do little about these skin conditions, excepting to realize that these skins fetch a much lower value.

A summary of the agents that affect the quality of skins is given in Table 2.

TABLE 2

Summary of agents that affect the quality of skins

Common name	*Causative agent*	*Type of damage*
PARASITES		
Maggots	Flies of the species *Lucilia* (green bottle) and *Sarcophaga* (flesh flies) *Calliphora* (blue bottles)	Infest wounds and sores, causing holes in skin
Warbles	*Hypoderma bovis* (C) *Hypoderma crossi* (S) *Hypoderma lineatum* (C)	Pin holes to fairly large holes on either side of the line of back bone.
Mange	Sarcoptes and psoroptes	Hairless patches on skin and grain damage
	Demodex (C, G)	Thin circular areas, nodules, holes
Ticks	*Boophylus sp.* (S,G) *Hyalomma sp.* (S,G)	White spots on flesh side which fail to dye.
VIRUS		
Pox	Pox group of virus (S,G)	Extensive circular lesions all over the skin both on grain and flesh side.
TRAUMATIC		
Brand mark	Hot branding	Branded scars of all sizes and shapes
Scratches	Fences and thorns	Slight grain damage to deep scars
Holes and punctures	Hooks and pecking by birds	Loss of skin
Hair slip	Bacterial putrefaction of skin	Grain damage to total loss of skin

S—Sheep, G—goat, C—cattle

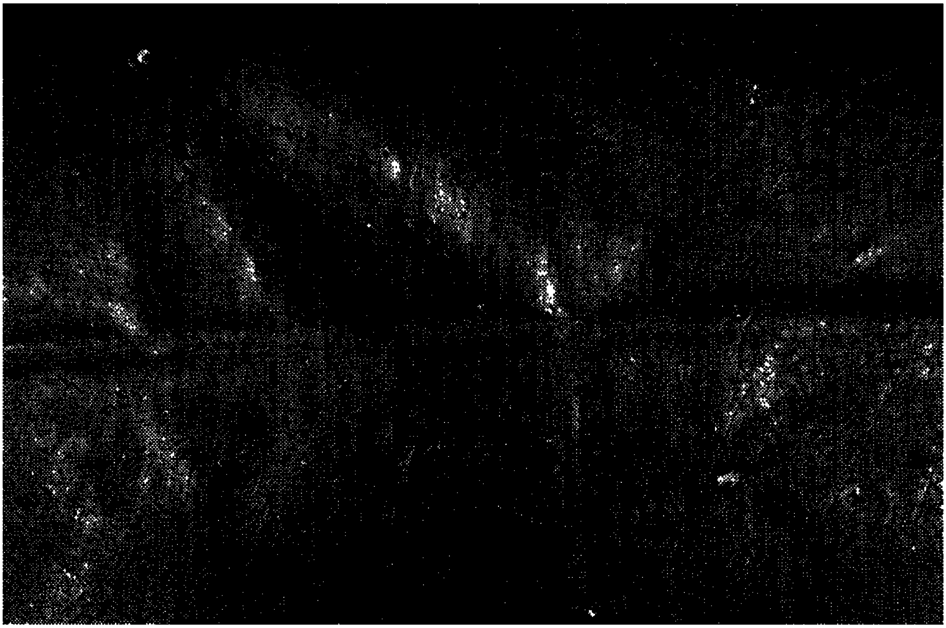

Fig. 6 : A skin damaged by warble holes

POST-MORTEM EXAMINATION

Body cavity

When the animal is cut open the body cavity is exposed which contains all the visceral organs. Cysts, an intermediate stage in the life cycle of certain tapeworms may be found adhering to the walls of the cavity or may fall off when the animal is opened. These appear like thin transparent polythene bags containing a watery fluid. These cysts contain the infective larvae of certain flatworms, the significant among which is the *Cystecercous tenuicolis* (Fig. 7).

These cysts can cause harm to man, being harboured as abnormal hosts and forming cysts in the organs of his body. These cysts called bladder worms are swallowed by dogs and they develop into tapeworms in their intestine. This worm in the dog intestine is the *Tinea hydatigena* which grows to maturity there and produces eggs which are excreted in their stools. These eggs which might contaminate the grazing fields of cattle are injested by them, thence to develop into cysts described as seen in the body cavity of animals. These eggs when accidentally injested by man, also develop into cysts. But the imminent danger to man exists both from the accidental injestion of eggs as well as by letting it to be swallowed by dogs.

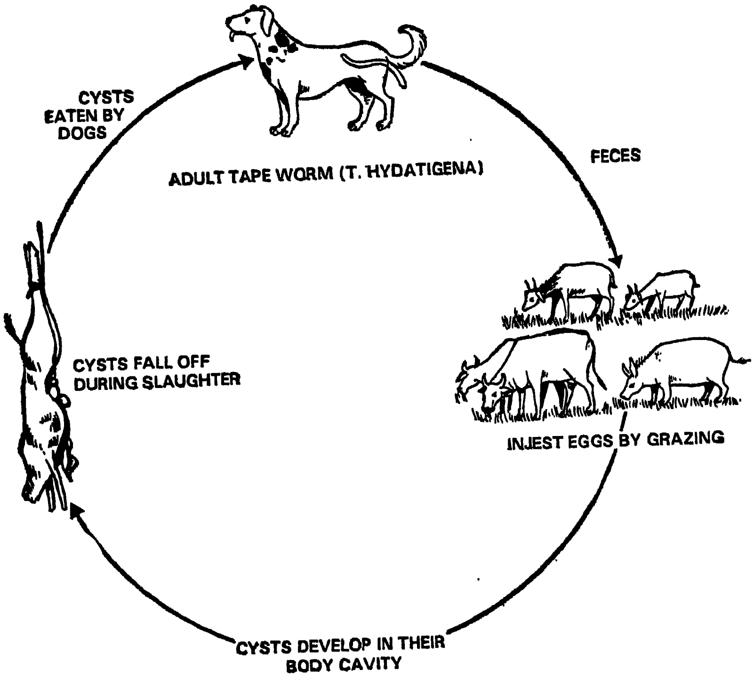
CYSTS EATEN BY DOGS
ADULT TAPE WORM (T. HYDATIGENA)
FECES
INJEST EGGS BY GRAZING
CYSTS DEVELOP IN THEIR BODY CAVITY
CYSTS FALL OFF DURING SLAUGHTER

Fig. 7 : Life cycle of dog tapeworm *T. hydatigena*

While dealing with the subject of cysts, some other cysts, not necessarily found in the body cavity but in other locations (e. g. musculature) are also discussed here.

Cysts in other locations

Another tapeworm *Tinea solium* (Fig. 8) is a tapeworm of man for which pigs are the intermediate hosts. The cysts are found in the musculature of pigs. These cysts termed as *Cystecercous cellulose* cause a milk-white or opalescent appearance to the musculature, and are injested by man by consuming pork especially raw or improperly cooked. Dogs also act as intermediate hosts with the cysts located in the brain causing symptoms in dogs which resemble rabies. It is suspected that cattle, sheep and goats may also harbour these cysts in different locations. The most important aspect in this is that man can act as a reverse intermediate host by injestion of these cysts, thus developing not only tapeworm as the main host, but also harbour *Cystecercous cellulose* as an intermediate host, thus suffering the disease in both ways. Utmost care should thus be exercised while rendering the carcass of pigs, but cysts from ruminants also cannot be taken lightly.

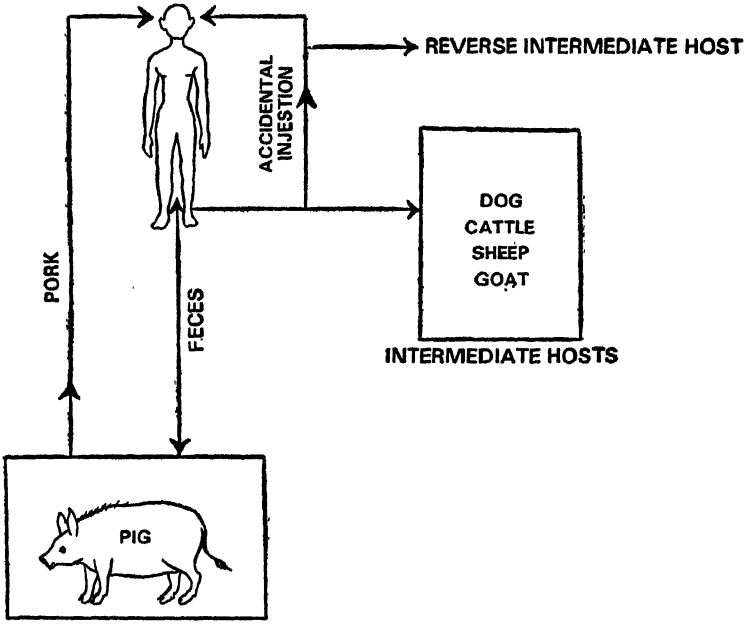

Fig. 8 : Life cycle of human tapeworm *T. solium*

The cystic stage of the dog tapeworm *Tinea multiceps* infects sheep, goat cattle, and horses and occasionally man. These infect the central nervous system affecting the brain and spinal cord. The cysts liberated when animals are opened, in turn, complete the life cycle through dogs. The cystic stage of the tapeworm *Coenurus cerebralis* may also be found in the pelvic organs of the animals.

Hydatid cysts (Fig. 9), the larval phase of the dog tapeworm *Echinococcus granulosus* may be found distributed in the lung, liver and any other location in the body. Hydatid cysts occur in almost all animals including dogs and man.

Tinea saginata is another tapeworm found in the small intestine of man. Cattle are the intermediate hosts and the cysts, *Cystecercous bovis* are found in their musculature. Man succumbs to the parasite by either consuming imporperly cooked beef or through consumption of raw beef juice prescribed for the treatment of pernicious anaemia. The cysts from handled carcasses could also be accidentally injested by man causing a potential infection hazard. It is of interest to note here that eggs defaecated along with stools of man are not directly infectious to man. The parasite completes the life cycle, the cattle serving as intermediate hosts. Though cattle are not known to suffer any harm by harbouring these cysts, cattle pick out infection from pastoral lands manured with human feces.

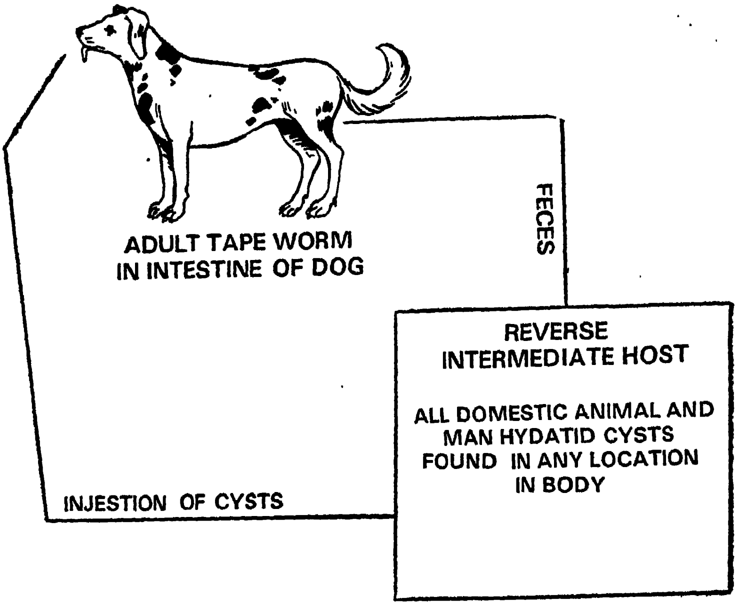

Fig. 9 : Life cycle of dog tapeworm *E. granuloses* which causes hydatid cyst in man and animals.

The above account brings two important aspects for consideration. While the carcass utilization centre aims at providing economic benefits, carelessness in handling of carcasses by ignorant operators could bring ill-health to man. The second aspect that is obvious is that dogs could be a potential menace and are the most unwelcome intruders in the premises where carcasses are rendered. No effort should be spared to prevent the entry of dogs into the campus.

Body fluids

The body cavity may contain large quantity of fluid. The accumulation of such fluids is a result of unrestricted permeability of the membranes of internal organs. This fluid is usually yellow to dark brown, the colour imparted by blood. In certain diseases as peritonitiis or ascitis, the fluids may amount to as much as ten litres in volume, and they drain out as the animal is opened. Such fluids as such are not of any significance to rendering.

Peritoneal fat

Peritoneum is the membrane that envelops the abdominal cavity and folds itself in a complex way to form the supporting membranes for the stomach and intestines called the omentum and mescentry respectively. In well fed animal carcasses, peritoneal fat is widely distributed as plaques over this membrane and this peritoneal fat can be recovered for separate processing as tallow if collection in large quantity is possible.

Thorasic cavity

The thorasic cavity contains the heart and lung and blood tinged liquid may also be found in this area.

The examination of organs

A closer examination of the organs is not necessarily warranted, when carcasses are dismantled for rendering. These are however likely to contain infectious agents harmful to animals and to man and should therefore be handled to the minimum extent possible or suitable measures taken if any organ cotaining infectious agents become exposed. Table 3 is an animal and organ-wise list of some pathological conditions of organs that may be encountered in the process of dismantling carcasses.

Bacterial infections

Bacterial diseases of animals are diagnosed by the symptoms they manifest prior to death or by lesions they produce when the animal dies of such infection. There are very many bacterial diseases that occur in animals but only a few are of direct significance to the rendering unit. These are fatal infections such as anthrax, tetanus and tuberculosis and non-fatal salmonella infections (fatal in calves). These bacterial diseases are also communicable to man.

Anthrax

Anthrax is caused by the bacterium *Bacillus antharacis*. The disease shows itself suddenly and death usually results within 48 hours after infection. Cattle and pigs are most commonly infected. The disease does not often spread rapidly, as infected animals die fast and the infection thus becomes self-limiting. The symytoms before death are not typical and when death ensues dark coloured blood oozes out from nostrils and anus.

Animals that have died of anthrax, or suspected to have died of anthrax are forbidden to be opened by law. The flaying of skin of such animals is also

TABLE 3

Comprehensive list of disease producing agents of importance to a carcass inspector

Disease in man	*Causative agent*	*Hosts*
PARASITIC		
Cysts in any location in the body	*Cystecercous teneucolis*-an intermediate stage of the dog tapeworm *Tinea marginata*	Adult tapeworm in dogs. Cysts found in body of animals
Cysts in any location in the body	*Cystecercous cellulose*-an intermediate stage of human tapeworm *Tinea solium*	Adult tapeworm in man. Cysts found in the musculature of animals.
Tapeworm in the intestines of man	*Tinea saginata*	Cattle–*Cystecercous bovis* found in musculature
Cysts in any location in body including brain	*Tinea multiceps* (Dog tapeworm)	Cattle, sheep, goat. Usually brain and pelvic organs
Hydatid cysts in any location in the body	*Echinococcus granulosus* (Dog tapeworm)	All animals. Cysts found in almost any organ.
BACTERIAL		
Tuberculosis	Bovine and human species *Mycobacterium tuberculosis M bovis*	Cattle–all organs especially lymph nodes and lungs
Malignant carbuncle	*Bacillus anthracis* (acute bacterial infection)	Cattle-animals suspected to have or died of anthrax should not be opened
Tetanus	*Clostridium tetani*	An ubiquitous organism found in soil, water and animal excreta
Food poisoning and gasteroenteritis	Salmonella species of organisms	Animals may harbour these organisms in their intestines without any symptoms
Undulating fever	*Brucella* sp.	Goats, sheep, pig and cattle
RICKETTSIAL		
Q fever	*Coxiella burnetti*	Cattle, sheep, goats and bandicoots
SPIROCHETES		
Leptospirosis	*Leptospira sp.*	Cattle, pigs
VIRUS		
Ornithosis	Large virus	Birds
Rabies	Neurotropic virus	Dogs, cats, wild carnivores and all mammals

forbidden. The whole carcass must be suitably disposed* and in case the cause of death is suspected or identified as anthrax after the animal has been opened, the implements and the environment should be properly cleaned (see guide-lines for disposal of anthrax carcasses in this chapter).

The danger from anthrax will be imminent when we realize that these are spore-forming bacteria and there are records to prove that these spores have survived in soils for as long as 32 years and be viable to produce the disease. The spores are killed by moist heat, for example, by prolonged boiling in water (100°C) for a few hours. The usual period they reside in a viable state in soil is three years.

Anthrax produces acute fatal illness in cattle, causing loss of animals and with no prospect of recovering any by-product including skin. Anthrax is known to infect almost all animals including man. In man, it produces a condition called malignant carbuncle. Inhalation of spores of anthrax bacilli can produce lung infection in man (commonly acquired from a wool factory-wool sorters disease) which could be fatal.

Tetanus

Tetanus in animals and man is caused by a spore-forming bacilli *Clostridium tetani*. Tetanus spores are ubiquitous in the environment and the bacilli colonise wounds. Tetanus bacilli do not produce any systemic infection in animals or man, but produce toxins from the site of wound which ascend through nervous system and could lead to a fatal sequel by causing respiratory paralysis. Animals that have died of tetanus are rigid (even immediately after death) and appear to have assumed peculiar postures. The head may have been twisted upwards or legs peculiarly twisted. Animals that have died of tetanus can be rendered in the normal way.

One general warning in respect of tetanus is noteworthy. Whether tetanus infected animals are rendered or not the personnel in the unit should maintain a strict level of personnel hygiene. In case any person is accidentally injured or bruised, he must wash the injury in clean water and soap. He must also seek medical advise for immunization against tetanus whether tetanus infected carcasses are handled or not. The tetanus spores as stated earlier are present everywhere, particularly in the neighbourhood of dung and filth and hence this precaution.

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*Whole animal rendering equipments are usually maintained in very large and well organized farms and this will be one of the best ways to deal with this dangerously infective carcass. The meal obtained from such rendering will be high in fibre as stomach contents and hair from hide have also been mixed up and usually useful for fertilizer provided sufficient care has been taken to properly render the carcass (minimum 3 kg/cm^2 /40 psi for 1½ hours)

Tuberculosis

Precautions to guard oneself against accidental contact with tuberculous organism and measures to prevent the same have been discussed in chapter 4.

Salmonella

Salmonella organisms are present almost everywhere in the environment and polute human foods, water supplies, animal feeds, etc. These bacteria when present in sufficient numbers in these materials can induce gasteroenteritis, fever and other non-specific illness and occasionally deaths. The spread of salmonella from carcasses, with which they are invariably infected, can be avoided by adapting hygienic practices and proper sewage disposal systems. It is not advisable to locate carcass, processing centres in the vicinity of water courses or lakes, particularly those which serve as public water supply. Although rendering process kills salmonella totally, recontamination of offal meals from the environment is highly likely. Sterilization of offal meal by fumigation with ethylene oxide or propylene oxide, gamma irradiation or exposure of feed mix with 10 per cent moisture for 2.5 to 3 minutes at 99°C are effective in destroying the contaminating salmonella. Salmonella contamination is considered as a major problem when offal meals are manufactured for export to other countries. Most countries importing animal products insist on certification for freedom from salmonella contamination.

VIRUS DISEASES

Rinderpest and foot and mouth

Rinderpest and foot and mouth are the important virus diseases of concern to the renderer. In areas where veterinary administration is sound, these diseases are identified and intensive measures to check them by quarantine, isolation and slaughter are taken up. Rinderpest could be fatal. Animals usually survive an attack of foot and mouth. The carcasses of animals that have died of virus diseases in their infective stage are not usually available for rendering and are slaughtered under veterinary inspection to be incenerated or buried. Whole animal rendering units if available are most ideally suited for their economic disposal.

Rabies

Rabies is a virus disease of carnivores, of which the dog as a host is the animal of direct concern to humanity. While all mammals are susceptible to rabies, rarely does a renderer comes across cattle, sheep, goat or swine that have died of rabies. If the history of death indicates that the animal is dead a few days after a dog, fox or jackal bite, there is every reason to suspect death due to rabies. It is difficult to look for any clues either from general appearance or through gross post-mortem examination, to confirm death due to rabies. Profuse salivation prior to death is a leading clue but not a confirmatory one. The examination of stomach contents of cattle may at times reveal that they have eaten unusual objects prior to death. This again may not be confirmatory unless correlated with a prior history of dog bite. Strange foreign objects may form a part of stomach contents in animals that have died of acute starvation as stated earlier or in animals that die due to phosphorous deficiency.

In any case, if the history of death indicates that the animal was earlier a victim of dog, fox or jackal bite, it would be unsafe to flay the skin or render such a carcass. The animal may be disposed by methods suggested for anthrax.

Clinical confirmation of death due to rabies is only obtainable by examining a section of hippocampus gyrus in the brain under a microscope for Negri bodies.

Recent interest in the utilization of carcasses of stray dogs for rendering has been a subject of controversy in countries where rabies is endemic. A discussion on this aspect may be found in chapter 9.

Guide-lines for the disposal of infected materials

Some general information and instructions have been provided under each of the conditions described. The procedures described are in general applicable to all types of infective materials. A separate set of guide-lines for disposal of anthrax infected carcass is also given.

Incineration

All types of infective materials, be it parasite, bacteria or virus, are destroyed by incineration. Provision for an incinerator in the rendering unit would be most ideal. A design for one such incinerator to handle two large cattle carcasses is given in Fig. 10.

Chemicals

Certain chemical disinfectants can effectively deal with infective material if used properly. These chemical disinfectants are handy if only small quantities of material need to be treated. These would prove uneconomical for large scale use in general.

Formaldehyde

A 10 per cent solution of formaldehyde or a 5 per cent solution of phenol in water, or other commercially available disinfectans are effective for disinfecting tools, implements, equipments and floors of the rendering unit. Potassium permanganate (2-5 per cent solution in water), or bleaching powder may also be used. Floor and toilet disinfectants meant for domestic use are not usually effective as they have very low concentrations of disinfecting agents and invariably contain larger amounts of masking agents that provide agreeable smells.

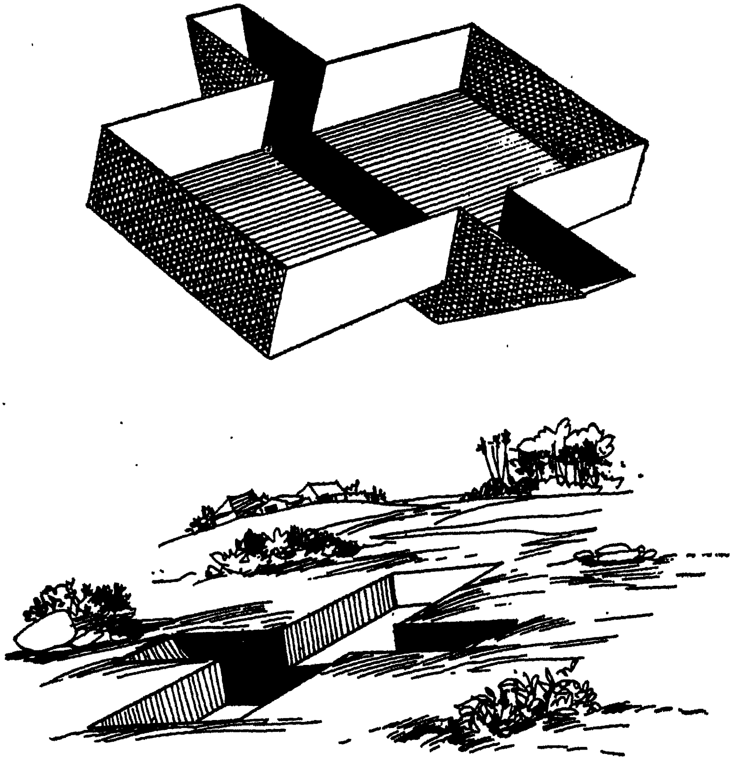

FIGURE. 10 : AN INCINERATOR TO INCENERATE CARCASSES.

The figure shows a model (top) explaining how the pit is constructed. The pit dug on the ground (bottom) is 2 X 1.5 X 0.5m. Across the pit is dug a trench 30 cm wide and 30 cm deep. The trench extends to reach the ground 0.75 m from the edges of the pit. The trench facilitates lighting fire and provides ventilation. The cross trench is layered with straw, previously soaked in cumbustible oil, this straw extending out of the trench on either side to provide lighting points. The pit is covered with logs, wood chips or coal, taking care not to obstruct the free flow of air across the trench. The carcass is placed in the pit and burnt (Adopted from : Diseases of Animals Law, J. L. Thomas, Police Review Publications, London).

When subjecting infective materials to chemical treatment sufficient time must be allowed to effect the destruction of the infective agents. Most of the chemical disinfectants are slow in action and therefore sufficient time (8-12 hours) should be allowed to elapse before considering the infective material to have been rendered innocuous. The chemically treated offals if any (e. g. lymph nodes or organs) should be later buried deep in the soil. They should not be combined with rendering stock, as they may be toxic due to chemicals used or introduce unacceptable odour to the final product, even if they are in very low concentration.

Lime treatment

Lime is cheap and is usually available in most areas where carcass rendering plants operate. Although lime can disinfect, meaning it will be lethal to most infective organisms, it is very slow in action. Condemned materials mixed with lime should not be allowed to dry out, as dry lime has no action. Thus pits may be dug in the ground, or cement troughs constructed of suffient sizes, such that lime in atleast ten times the quantity of infected material can be mixed. The material mixed with lime is allowed to remain in the pit for several days and wetted frequently with water to prevent drying out. Pits where lime treatment is done may be closed and abandoned safely for as long periods of time as possible (also see lime treatment under disposal of anthrax carcasses).

Salt

Although salt is extensively used for the preservation of hides and skins, salt does not effectively destroy infective organisms. Spore-forming organisms such as anthrax, tetanus, and clostridia remain dormant as spores in the presence of salt and will revert to infective stage once salt is washed away. Salt can thus be used only as a temporary preservative to prevent putrefaction (See water activity, chapter 10.)

Boiling

Boiling, if done effectively for sufficiently long periods of time, does disinfect; but it is difficult to assess how much boiling is sufficient. Many spore-forming organisms, tuberculosis bacteria and certain intermediate stages of parasites survive boiling especially if they are embedded deep inside the tissues.

Autoclaving

Autoclaving is boiling at a higher temperature, a technique akin to wet rendering. Specially designed vessels are used for autoclaving (Fig. 11) and autoclaving at 1 kg/cm^2 (15 psi) for 15 minutes is sufficient in most cases, to render the treated products sterile. Autoclaved offals are suitable for transfer to the rendering plant as they are safe to handle. An autoclave is ideally suited to sterilize equipments and clothing used in a rendering plant, in case they are suspected to have been soiled with infectious materials.

Disposal of Anthrax Carcasses

The disposal of anthrax carcasses is a responsibility of the animal health services as it is a notifiable disease, but it is likely that such carcasses at time fall inadvertently in the hands of a rendering unit. Under such circumstances, it is the primary responsibility of the renderer to intimate the veterinary authorities at the first intance. The following guide-lines provide instructions in case the animals infected with anthrax have either been brought for rendering or flayed by accident.

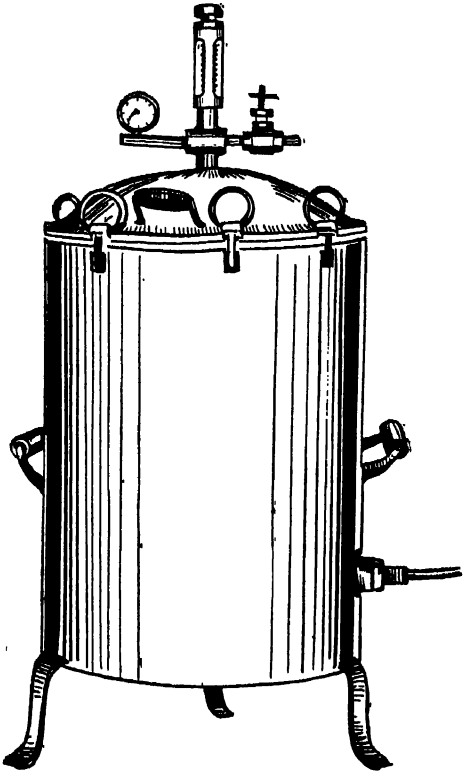

Fig. 11 : Autoclave — sterilizer

The site where such animal was flayed should be covered at least 30 cm deep with lime and kept wet by sprinkling water. The area should be cordoned off with a temporary fence to prevent entry of stray animals. The skin and the carcass are preferably buried at site or should be buried as follows.

While selecting a site for a pit for burial, care should be taken to see that the pit is far away from water courses or do not pollute ground water table. The animal is buried at site (usually owner's land). A three metre deep pit is covered with lime at the bottom to a height of 25–30 cm. The animal is then lowered into the pit and covered again with 25–30 cm height of lime and then closed with mud. The soil should be hardened to prevent digging up by carnivorous animals (dogs).

All the implements, ropes, chains, knives, showels, etc., used for burial should be disinfected (formalin or boiling water or autoclaved as described earlier) and the straw, litter and other associated materials burnt. The area of land or the ground where the animal was lying should be disinfected or burnt with kerosene and straw, covered with a layer of lime and fenced off for about one month. Farm carts, wheel barrows, and such transport vehicles that are suspected to be contaminated are sprinkled with moist lime or painted and washed after an interval of at least 15 days. The washings are best discarded into lime pits.

Persons involved in the disposal of the carcass and associated materials should disinfect themselves and their clothing. The persons should wash themselves well with a disinfectant lotion or soap and disinfect their clothing either by treating with a strong disinfectant soak or best by autoclaving. Accidental infection in man can cause cutaneous infection producing malignant carbuncles.

Summary

The infectious agents discussed and additional agents are listed in Table 3. Table 3 is comprehensive but by no means exhaustive or complete. For those interested in greater details and an in-depth study in this important area, the references cited may give a lead.

CHAPTER—VI

Preparations Prior to Rendering

The carcass after post-mortem inspection is essentially split up into the following components: skin, viscera and the rest of the carcass containing musculature, internal organs, and bones.

The skin

The separatad skin is cured either by salting or frame drying. Only a brief account of these techniques is given here and details will be found in references cited.

WASHING THE SKIN

The flayed hides (the term hide refers to the skin of cattle and other large animals ; skin usually refers to skin of sheep and goat in the common parlance of leather industry) should be washed in clean water and then allowed to drip by hanging on a wooden horse (Fig 12). The dripping may be allowed to continue for a maximum time of not more than four hours. Under normal conditions dripping the hide free of water should be completed in half an hour.

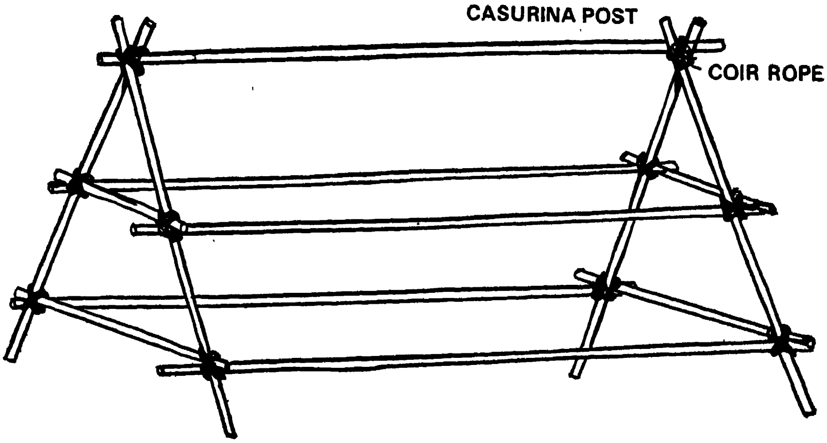

Fig. 12 : An improvised horse for drip-drying of hides

SALTING

The hides are salted by the application of common salt on the flesh side. Usually 30-50 per cent of salt based on the weight of the hide should be sufficient. For example, a hide weighing 20 kg will require around 6-10 kg of common salt, the quantity dependent on method of application and the size of salt crystals. Powdered salt is ideal, and large crystals of salt are likely to cause physical damage to hide. The salted hides are folded with grain side out into convenient sized bundles. The salted hides are stored in the coolest part of the store, until sold to leather manufacturers. Salted hides are preferably stacked on a raised platform having a slatted surface, so that the extruded water drains away. Hides thus salted and stored can remain without spoilage for seven to ten days. If further storage is envisaged the hides are re-salted and stored. Prolonged storage leads to drying and such hides are difficult to wet back for tanning.

DRYING

Drying of hides is an ancient practice. Dried hides are still available from many tropical countries of the world. Drying of hides is done by stretching and tieing the hides on a frame. The framed hides are allowed to dry in shade. Hides dried directly under warm tropical sun dry too hard and become rejects when sold to a tannery. Drying should be prefered only as a second alternative to salting.

Viscera

Viscera in the context of discussion here is taken to be composed of the stomachs, intestines, and all internal organs. The internal organs namely the lungs, heart, liver, pancreas, spleen and kidney can be combined without any further processing for rendering with the rest of the carcass.

The stomachs and the intestines should be emptied of their contents and washed prior to being included in the rendering stock.

WASHING THE STOMACHS

The stomachs are cut open into as flat sheets as is practicable. The stomachs are most conveniently washed after the contents have been discarded with the help of a jet of water from a hose. Alternatively, these can be washed in a tub manually. Machines which very effectively wash the tripes are available but these may not work out economical for the carcass utilization unit.

WASHING THE INTESTINES

Intestines are pulled through a pair of round sticks held like barnacles. Further washing may not be necessary unless too much of injesta or fibrous matter is present. The idea of washing the stomach and intestines is mainly to remove the cellulose contributed by the feed. Leaving a large amount of injesta unwashed will give rise to high fiber content, lower nitrogen in final analysis of meat meal which is undesirable from quality and cost point of view.

FATS

While separating the stomachs and intestines, the omentum and mescentry, the membranes that fasten stomach and intestine, may be found to be loaded with fat. This fat-loaded membrane can be included with the general rendering stock. If facilities are however available to process fat separately, these may be collected and stored separately in a bucket. Similarly, a rich store of fat may be found around the kidneys and adhering firmly to the pancreas. These are also either included in the general rendering stock or separated for processing fats differently.

CONTENTS AND WASHINGS

The stomach contents constitute a great bulk of material, about 25-40 kg per animal. An additional sludge will also be obtainable as sediments from washing tubs or other containers where stomachs and intestines were washed prior to being taken for rendering.

The rest of the carcass combined with the internal organs and washed stomachs and intestines is taken up together as the rendering stock.

Practical considerations

FLAYING

Flaying can be done totally on the ground or partly on the ground and partly by hoisting the animal over a hook or pulley. With the carcass lying on the ground, the animal is turned to rest on its back and an incision is made with a flaying knife to extend from medial (ventral, inner) side of one hind leg to the other. The incision is usually begun at the belly just behind the mammary gland in the case of female animals or from behind the scrotum in case of bulls or bullocks and extended on either side to the hind legs (Fig. 13). While flaying carcasses for meat the incision is not usually extented beyond the hock joint. But in a rendering unit the incision may be extended as far back as the dew claws. A circular incision is now made across the limb and the skin flayed either downwards (difficult) or upwards from the belly to either limbs (usual practice). An incision is now made along the median line of the abdomen (Fig. 13) to extend upto the base of the mouth. The skin is freed as much as possible and the animal is either hoisted for further flaying or flayed completely on the floor. Care should be taken to run the knife along the median line of the abdomen with the sharp edge of the knife upwards, as this guards against inadvertently cutting open the abdomen. If abdomen is by accident cut open, foul gases may be emitted or the stomach contents spilled out which not only spread and soil the skin, but will also enter inside the carcass, soiling the inner side

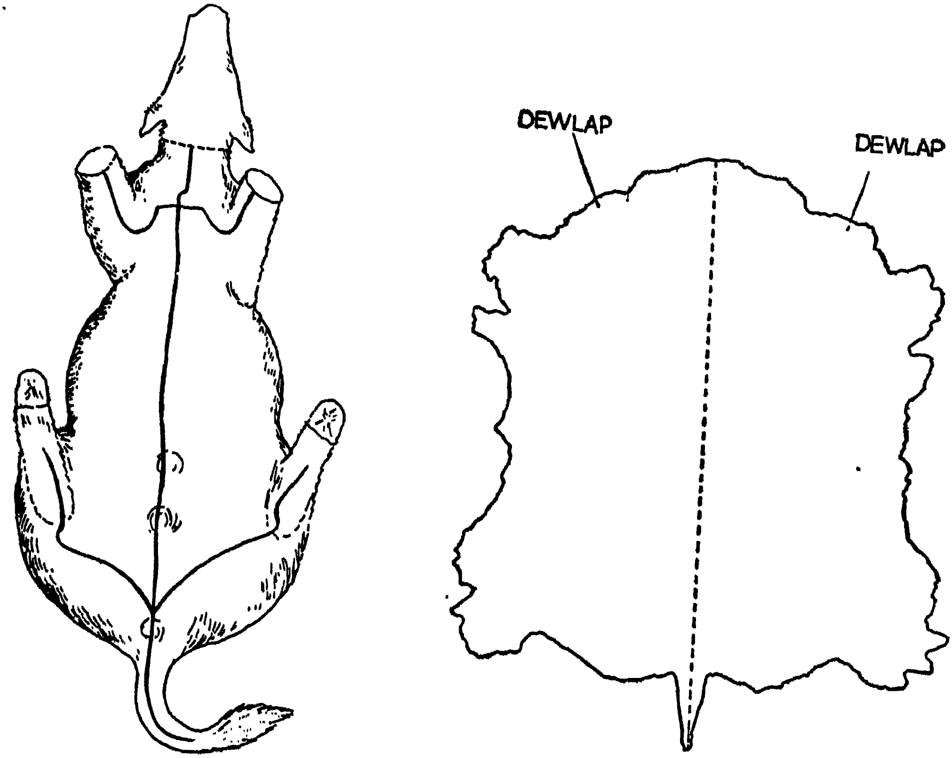

Fig. 13 : Flaying lines marked on a carcass to start flaying and a correctly flayed hide.

of the abdominal cavity. Any effort taken to prevent this from happening is worthy, as otherwise more time and labour will be spent in cleaning the soiled portions. It is more convenient to flay an animal when hoisted on a pulley over the tripod (Fig. 5). While flaying every care must be taken not to make any cuts on the skin surface, as these flay cuts seriously undermine the value of skin. It is for this reason that it is desirable to employ trained flayers or offer training in flaying prior to taking up this work. Flaying of the fallen animal skin may be done exactly in a manner similar to the flaying meat animals. But as there is sufficient time at the disposal of a carcass flayer, it is better to remove the entire skin of the animal including the one covering the lower portions of the limb, tail, and head. This extra area of skin flayed is usually trimmed off prior to tanning operations, and goes as valuable trimmings, an ideal raw material for the manufacture of glue.

WASHING

Properly flayed skins are fairly clean on the flesh side, except for some stains produced by blood or serum. The hair side of the skin may be dirty and therefore the skins are preferably washed on both sides by a hose after spreading on the floor, or hung over a wooden horse (Fig. 12) on which it may be turned conveniently to wash both sides and allowed to drip. Several skins may be washed, piled and allowed to drip. The washed skins can now be salted or dried by the method suggested earlier.

VISCERA

A shallow wheel barrow, a tripper dumper or any such vehicle will be ideal for collecting the stomachs and intestines. Alternatively these may be collected on a gunny or jute cloth and dragged away from the rest of the carcass. It is not essential to detach any other visceral organ, but they may have to be removed before the carcass is cut down into smaller bits for loading into the renderer. The separated organs namely the lungs, heart, liver, and kidneys may be directly transferred to the renderer. The spleen will be found attached to the stomachs and is separated and transferred to the rendering vessel. If fats are separately rendered the fat around the kidney may be separated.

The separated stomachs and intestines are emptied and washed as described earlier. The stomach and intestinal contents must be collected separately and disposed.

CARCASS

The carcass is now split into smaller pieces and it is not necessary to cut them into further smaller pieces than is minimally needed, especially if rendering units have an agitator. Minimum handling of carcass increases the hygiene of the unit, increases occupational safety for workers and involves less labour time.

Head

Horns if present are sawn off and any skin adhering to them is separated. The separated skin, if any, is salted and sold for glue stock as head piece. The head may be fed as such into the renderer or broken with an axe into small bits and then fed into the renderer along with the brain, tongue, muzzle, etc. The separated horns are rendered separately or sold to dealers in these materials.

Hoofs

The hoofs along with the shank (the lowest portion of the feet) is also separated and not put into the renderer. Hoofs do not digest easily while rendering and if rendered contribute to indigestable protein nitrogen undermining the value of meat meal. However, large scale renderers operating at steam pressures 5-8 kg/cm^2 (80-120 psi) can disintegrate and digest hoofs also. In this case, horns are similarly digested under these operating conditions.

The use of hoofs and shank bones for the production of Neat's foot oil deserves attention.

Separating fats

As stated earlier, the carcass fat can be separated or left to be rendered with the carcass. The worth of separation of fats depends on the size of the unit and it may not work out economical to process fats unless more than 50 kg are recoverable per day. Normally, 10-15 kg of fat is recoverable from a healthy adult buffalo carcass. The carcass unit seldom will be receiving healthy animals and hence at least 8-12 carcasses may be needed to obtain about 50 kg of fat.

The processing of fat, in the absence of other offals does facilitate the recovery of better quality fat, almost equal to prime quality fat obtainable from a wet rendering unit (see chapter 8). Demand for better quality fat and economics of production (fuel and labour) should be the criteria in making a choice for a separate fat processing unit.

When wet rendering process is used the fats need not be separated, as the quality of fats obtainable is fairly high.

Deboning

Deboning is not a commercial practice in large carcass rendering units. The reason for not deboning are many. Deboning involves intensive manual labour and is time consuming. The excessive handling of carcass for the purpose of deboning, as well as the prolonged time between dismantling and rendering lowers hygienic standards. This consequently affects quality of the end product due to natural deterioration. The odds of vulnerability of the carcass centre becoming an endemic foci for several human and animal diseases are aggravated by deboning operations. Some establishments however practise partial deboning. The three pairs of long bones of the fore limb and hind-limb (viz., humerus, radius and ulna, metacarpus of fore-limb, femur, tibia and fibula and metatarsus of the hind-limb) are removed. They are separated as they fetch good value. The fats contained in them is also at times recovered separately by boiling in an open kettle. The use of the recovered bones for uses other than bone ash or dicalcium phosphate is not recommended (explained below). In general, deboning thus includes partial deboning.

Deboning as a regular practice is not to be recommended, based on scientific and ethical reasons, in a carcass utilization centre.

It has been repeatedly stressed that a carcass utilization centre should not violate any public health codes and practices. Minimal handling of carcass, or handling only to the extent that is required for quick and efficient operational facilities should be advocated. Deboning could hamper this objective to a very great extent. Partial deboning as described above yields around 15-18 kg of bones, which when dried would weigh 7-8 kg (50 percent moisture content) and after removal of fat (15 per cent fat) would finally yield 6-7 kg of dry bones per carcass. One ton of bones can be accumulated in a unit processing five carcasses per day in this manner in about a month's time.

It is worthwhile and important to note here that regulations in most of the countries forbid the use of any product declared unfit for food to be used or returned in any form as food ingredients. The practice of deboning could result in a purposeful or inadvertent admixture of these bones with slaughter stock, either for recovery of edible tallow, or as a starting - material as crushed bones for the manufacture of food or pharmaceutical grade gelatine.

The above may not stand to reason, especially in the minds of those who are dogmatic about somehow solving world protein shortage and improving economy at rural level. To them the example cited below should stand to greater reason.

Deboning at the outset appears to offer the benefit of production of meat meal of higher protein content. Table 4 provides a proximate analysis of meat and bone meal, particularly deboned meat meal and meat meal.

A pragmatic look at feed formulations, the essential purpose for which the rendered offal meals are needed, indicates that the benefit of increased protein content derived by deboning is largely offset by the needed re-supplementation with minerals.

TABLE 4

A proximate analysis of rendered meals

	Per cent						
Rendered offal meal	*Protein*	*Fat*	*Moisture*	*Fibre*	*Pepsin indigestible residue*	*Ca*	*P*
Meat cum bone meal	50	9.5	10	3	14	9	4.5
Partially deboned meal	55	9	10	3	14	6	3
Meat meal	76	10	10	—	14	4 (as total ash)	

Taking the typical example of a feed ration for a growing pig of 9-20 months of age, for which offal meal is ideally suited as a component in feed rations, the total feed intake would be around 6 kg per day. A bulk of the feed contains carbohydrates and some fats, to provide the daily requirement of 3 M cal of digestible energy. The 6 kg ration should in addition contain 20 per cent proteins, 0.8 per cent calcium, 0.7 per cent phosphorus, and a balanced amount of other trace elements and vitamins. Thus the 6 kg of ration should have 1200 g. protein, 48 g. calcium and 42 g. phosphorus. Most offal product meals are not added as a component of rations in excess of 15 per cent. Offal meals added in excess of 15 per cent make the meal unpalatable to the animal. Thus a 15 per cent meat-cum-bone meal in the 6 kg ration permits addition of 900 g. From Table 4, it can be calculated to contain 450 g. of protein, 81 g. of calcium and 40 g. of phosphorus. The ratio of Ca : P added to rations is usually 2 : 1, to permit a balance in the absorption of phosphorus along with calcium and to compensate for losses in calcium due to the formation of insoluble salts of calcium in the digestive tract. The availability of calcium and phosphorus in excess is not harmful as it is present in the ratio of 2 : 1 and is thus balanced for calcium and phosphorus requirements. The protein being only 450 g. out of the total requirement of 1200 g, when supplemented with meat and bone meal fills only a third of the total protein needs. This is not a set back, as total protein requirements cannot be met by rendered offal products alone. Both meat meal and meat-cum-bone meal are useful as a lysine supplement and a source of vitamins of B complex, especially Riboflavin, Choline, Nicotinamide and B_{12}. They are poor sources of methionine and tryptophan (the essential amino acids). Thus vegetable proteins have to be necessarily added to meet other vitamin requirements and also to provide the needed bulk for the rations. Further, the ash in meat-cum-bone meal is rich in manganese, an essential element. It is also known to contain a certain enteric growth factor, the *Akerman factor* and another growth factor located in the ash. This example of pig feed ration, applies equally well to most other feed formulations in use.

The above discussion significantly justifies the fact that the production of meat-cum-bone meal is not only the most economical one for feed supplementation, but is also most practicable for rendering. The idea of deboning to enrich the protein level will be largely defeated by the need for the supplementation of minerals and other essential constituents and minerals from extraneous sources in feed rations. The same analogy applies when considering the manufacture of pet food formulations from carcass rendering.

To surmmarise, deboning as a regular commercial practice is not very much in vogue due to the following resons ;

1. Deboning is a manual operatian requiring labour and consequently causes undesirable delay in rendering.
2. Public health problems and maintenance of hygienic standards are greatly upset by deboning.
3. Enriching rations with offal protein only does not confer any special advantage. (Protein enrichments are usually done by judicious admixtures of fish meal, blood meal, vegetable proteins and oil cakes besides offal meal)

4. Deboning provides a venue for violation of regulations in regard to admixture of condemned offal bones with slaughter stock for recovery of edible fat or for use in edible gelatine production.

Notwithstanding the above reasons, the recovery of bones and the preparation of meat meal could still be practised under the following conditions.

1. The preparation of meat meal (without bones) could be the only way left in open kettle rendering. During the processing the bones easily separate after cooking and the rest of the offals are sperated, pressed, dried and powdered. Bones obtained through this process should not be used for the preparation of any edible product for human consumption.
2. The bones obtained either by open kettle rendering or by any other method should only be used for the manufacture of non-edible bone tallow or used for the production of bone ash for cattle lick, bone china or for the production of dicalcium phosphate.
3. If the carcass obtained for rendering is from a slaughter stock or from carcasses condemned in the abattoir or elsewhere for reasons other than public health or veterinary health hazard, these animals may be deboned. Examples of such animals are, pregnant cows condemned as unfit for human consumption, very old animals and carcasses soiled badly in the abattoir during handling, failure of cold room where meat purpose carcasses are stored, and such others.

International Regulations

International regulations and food legislations prevailing in most countries forbid the use of the following livestock products for use as food directly or in food formulations : Live and dead animals, carcass, meats, organs and offals declared unfit for human consumption during ante-mortem and post-mortem inspection ; and animals dead or killed by methods other than by approved slaughter practices. Trade in game animals is not a wide scale commercial practice and the consumption of their meats or parts there of without inspection is always at the risk of the trader and consumer.

TALLOW

It is for the above reason that tallow recovered by any method whatsoever from a carcass utilization centre, should be declared as inedible and this tallow is preferably denatured by admixture of petroleum products to clearly differentiate this from tallow of abattoir origin.

Bones

The risks involved in using bones of condemmed animals for the extration of fat or for the production of gelatine are the following : During extraction of fat the temperatures attained are not high enough to destory the miriad of microbes. Further, the heated fat can intrinsically offer protection to the destruction of microbes (akin to a high Riedel Walker coefficient in assessment of bactericides in the presence of organic matter). The first operation for gelatine production is crushing of defatted bones. The dust raised during crushing is enormous and could cause inhalation risks. These reasons forbid the use of dead animal bones and condemned animal bones for the above uses. Gelatine, if produced under controlled conditions from these bones, would be innocuous but the difficulties in defining and maintaining controls on the one hand and ethics on the other hand forbid the use of these bones for gelatine production.

Storage

Some of the basic factors that affect the quality of carcass material during storage are summarised below.

1. *Time :* Time is a factor that constantly works against quality, right from the procurement of raw material to the time the final product is marketed.
2. *Temperature :* An old rule in chemical reactions that every rise of 10°C doubles the rate of reaction, applies equally well here also. With rise in environmental temperature the raw material putrefies more and more rapidly due to the action of proteolytic enzymes inherent in the carcass and bacteria contributed by the resident bacterial population.
3. *Enzymes and bacteria:* Enzymes and bacteria compete adversely with the renderer's effort to maintain product quality and if not properly controlled, their damage could be irreparable.
4. *Moisture :* The nature's abundant solvent water which contributes to moisture is the one that conspires the primal need for rendering. The moisture is removed and the method or technique used for the elimination of moisture, contributes significantly to the quality of the end product.

Each of the above factors individually and collectively catalyses deterioration of materials both in the raw and finished from. These deserve a serious consideration and every effort made to minimize their assault on the quantity of the end product will pave way to greater returns.

From the above account one can conclude that it is not advisable to store carcass offals prior to rendering. The time interval between dismantling the animal and rendering should be as short as possible. If it is envisaged that rendering operations will be delayed, or falls in a shift before which the dismantled product should wait, it is preferable to keep the whole carcass waiting, rather than storing offals for rendering.

Should an exigency arise, that carcass offals should have to await rendering, the offals must be stored on a slatted platform from which any liquid would drain off. The storage should be done in a place protected from fly and carrion infestation. Storage of over 8 hours is not desirable under any circumstance. Drying carcass offals as a method of storage is discussed in chapter 10.

Refrigeration will be uneconomical for a carcass utilization centre. The advantages gained by cooler climatic zones or periods, where carcass can be stored longer, are largely offset, when one considers the net energy balance. In such climatic zones, the heat energy expended for rendering will compensate for the gain obtained in cooling. The only advantage in cooler climates will be the consolation that the cost of cooling equipments are usually out of proportion to that of heating equipments, thus providing a reasonable economic advantage for storage of offals.

CHAPTER—VII

Rendering and Rendered Products

Rendering process is an important area of activity not only for carcass utilization but also for utilization of condemned offals. As such rendering techniques will always be there and will continue to operate and expand and find several improvements and innovations, since inedibles from an abattoir must be disposed off with benefit. In this chapter, the principles and techniques for rendering, recovery of end products and the evaluation of their quality will be discussed.

RENDERING

The term 'rendering' was initially coined to refer to the extraction of fat or oil by heat. Rendering as a process is often extended to the techniques that aid in the recovery of fats and protein residue from animal offals.

Animal offals can be taken to contain essentially three components namely, protein, fat and water in varying proportions depending on the source. Rendering operations aim at eliminating the water and recovering the proteins and fats of optimum yield and quality.

Open kettle rendering, wet rendering, dry rendering, and impulse rendering, are some of the different techniques of rendering adapted. A perfect rendering process should have the following charecteristics.

The process must be

1. sufficiently flexible to handle economically and efficiently all classes of raw materials to which it may be applied.
2. capable of operating efficiently under varying load conditions without detriment to final quality of the product.
3. self contained, clean and provide maximum amount of saleable material and least amount of wastes.
4. mechanically simple requiring minimum maintenance, repair and replacement and of low capital investment.

The process should

5. require a minimum investment of labour, electrical and chemical energy.
6. be capable of producing uniformly high quality end products and maintain this uniformity, irrespective of variables to the extent possible.
7. not be affected by vagaries of weather, seasons, and day-to-day operating conditions.
8. not pose any industrial risk, occupational hazards, cause health or pollution problems.

It is obvious to any one that the ideals stipulated would be hard to achieve totally, but every effort made towards these ideals will add more income to the investor.

Basic principles

Animal offals contain three broad components namely, water, protein, and fat in varying proportions. Mineral matter contributed by bones joins with the protein residue and as such need not be considered here separately. Water is the major constituent of animal offals as they contain 60–80 per cent water. Fat is contained enclosed in cells and widely dispersed with protein matter. The ratio of fat to protein varies greatly with the type of animal offal processed. Whole animal carcass prepared for rendering contains approximately 65 per cent water, 18-25 per cent protein (and minerals) and 10–15 per cent fats. Table 5 provides an approximate analysis of proteins, fats, and moisture in various parts of the animal carcass. A whole buffalo carcass weighing 277 kg will yield 200 kg of prepared carcass and will finally yield 70 kg of meat-cum-bone meal and 13 kg of dry tallow (Fig. 14).

Rendering involves heating the offals to temperatures at which the cells rupture, give up the fat that melts and also coagulate the proteins. When animal offal is cooked in a vessel sufficiently to cause these changes, it will ultimately separate into four layers by gravity—the protein residue at the bottom, a layer of water, a small layer of oil and water emulsion and an upper most layer of oil which is molten fat. In wet rendering, this is what exactly happens. Efficient separation of these components and maximum recovery of protein residue and fat are what constitutes an efficient rendering technique.

Open kettle rendering

Open kettle rendering is the most ancient process and is still widely adapted under rural conditions or in small farms. This process requires lowest capital investment, but much remains to be said as far as recovery of quality end products is concerned.

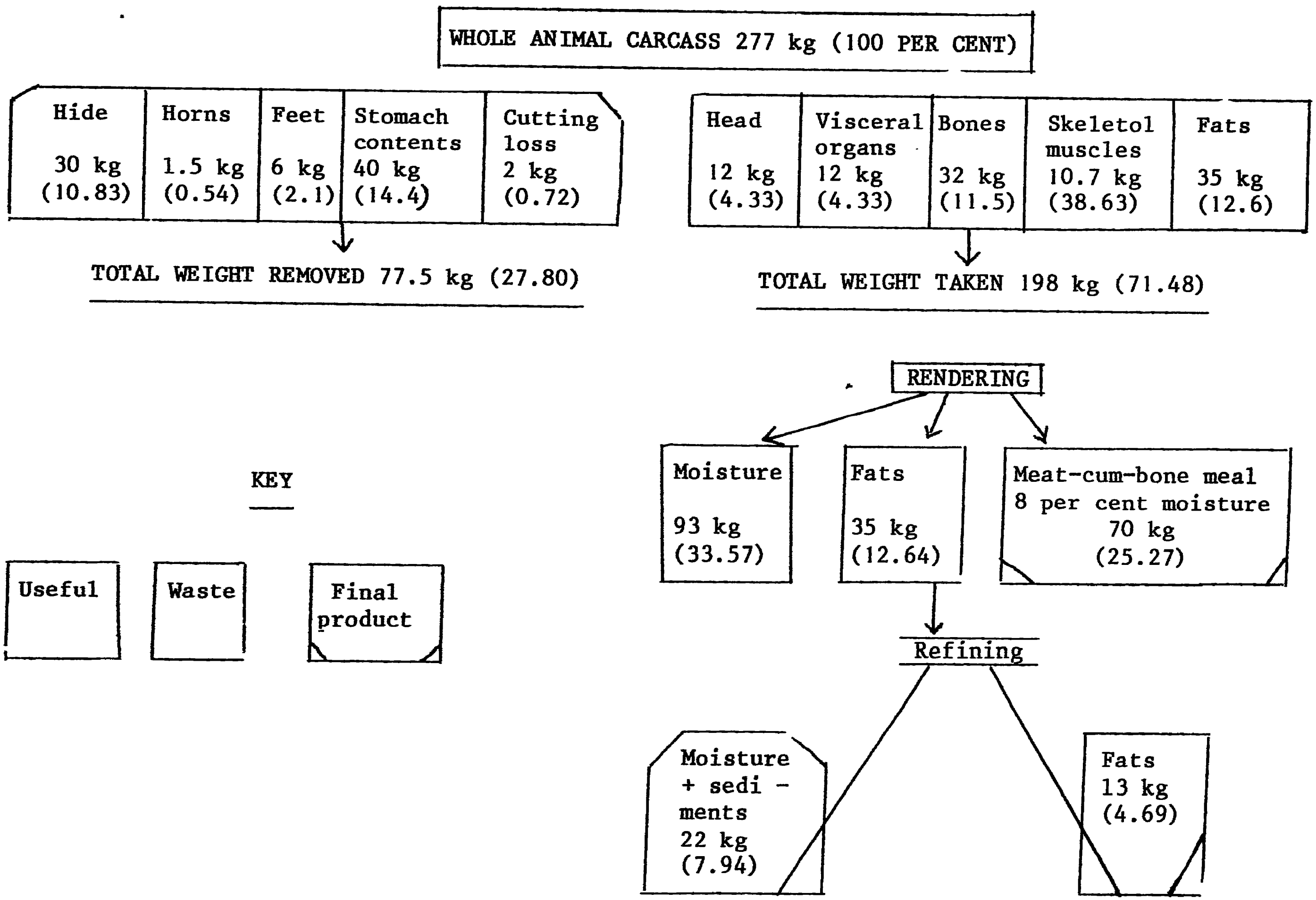
WHOLE ANIMAL CARCASS 277 kg (100 PER CENT)
Hide 30 kg (10.83)
Horns 1.5 kg (0.54)
Feet 6 kg (2.1)
Stomach contents 40 kg (14.4)
Cutting loss 2 kg (0.72)
TOTAL WEIGHT REMOVED 77.5 kg (27.80)
Head 12 kg (4.33)
Visceral organs 12 kg (4.33)
Bones 32 kg (11.5)
Skeletol muscles 10.7 kg (38.63)
Fats 35 kg (12.6)
TOTAL WEIGHT TAKEN 198 kg (71.48)
RENDERING
Moisture 93 kg (33.57)
Fats 35 kg (12.64)
Meat-cum-bone meal 8 per cent moisture 70 kg (25.27)
Refining
Moisture + sedi - ments 22 kg (7.94)
Fats 13 kg (4.69)
KEY
Useful
Waste
Final product

Figure 14. Rendering process break-up of losses and product yields

TABLE 5

An approximate analysis of buffalo carcass and ideal yields of offal meal

		Kg	Kg
Weight of whole animal			277
Materials not taken for rendering	Hide	30	77.5
	Horns	1.5	
	Feet	6	
	Stomach contents	40	
Carcass weight available for rendering			200
Carcass contains	Head	12	
	Liver, lung, spleen, heart, kidneys	12	
	Bones	32	
	Skeletal muscles	107	
	Fats	35	
		198	
	Cutting losses	2	
Actual weight of carcass rendered			196
Rendered products (moisture loss 65 per cent, i.e. 128 kg)			
Meat-cum-bone meal			59 61
Dry fat			7 8

It is not necessary, however, to condemn the process as useless, as open kettle rendering is still the most ideally suited one under rural conditions. This method could very well pave way in stages for adoption of improved processes

The cooking of offals is performed in containers of all descriptions, from a hemispherical dish to oil drums. The container is mounted at a convenient height over a brick oven, usually heated with fire wood. The carcass materials are chopped into small sizes (the size of bricks) and cooked in the container with sufficient amount of water. The mass is agitated constantly using a wooden pole (Fig 15) Not more than the material of one carcass is usually handled at one time and the

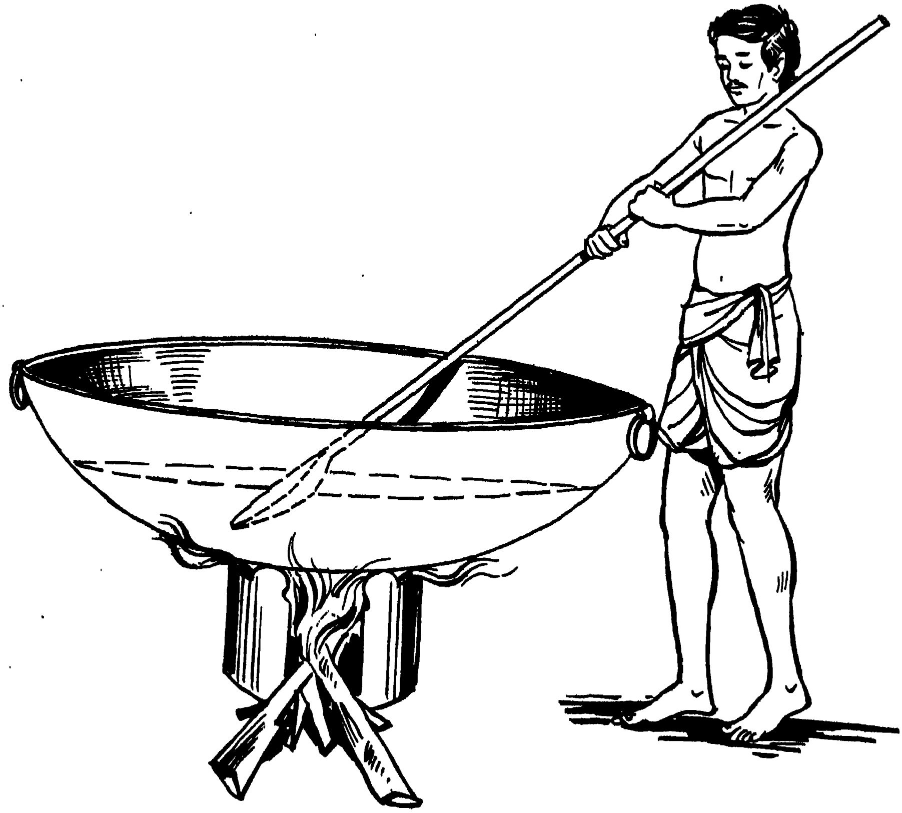

Fig. 15 : Open kettle rendering. The stirring is done manually using a pole.

cooking is complete in 4-6 hours. After the cooking is complete, the solids are shovelled with a fork, retaining as much of liquid in the container as possible and transferred to a perforated container mounted on a tripod (Fig. 16). A bucket provided below collects the water drained out. This drained out liquid is transferred back to the container in which the offals were cooked. The cooked solids after draining, may be pressed in a screw press or by other improvised methods. One such method is to collect the cooked offals in gunny bags, which are laid on a hard cemented ground and pressed with a weighted plank. Drying is generally accomplished by spreading out the cooked offal on a paved floor under sun. The dried mass is then ground into a meal after the separation of bones. The bones may also be separated from the wet cooked offals and then pressed.

SEPARATION OF TALLOW

The liquid part in the cooking vessel gradually separates into an upper oily layer and a lower layer of dissolved proteins. At times it may be beneficial to add salt to aid

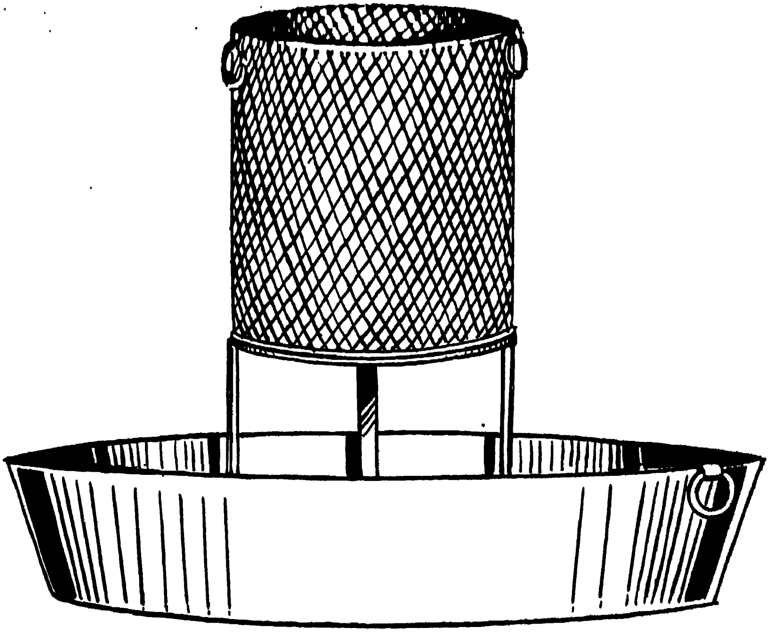

Fig. 16 : Filter vessel on tripod and receiver to drain water from the cooked offal.

the separation of oil from the 'liquid stick'. When salt is added, better separation of oil is effected due to the greater solubility of salt in the liquid layer. Salt also aids in separation of oil, by breaking up the oil in water emulsion formed during cooking. This product when left overnight, separates into an upper layer of semi-solid fat which is manually separated and collected in smaller drums. This is remelted by heating, filtered through cloth and the filtrate thus obtained is crude tallow.

The remaining liquid is usually discarded if salt has been added. If salt has not been added, it can be heated to a dry consistency and used as fertilizer. The liquid termed, liquid stick, can also be used as such as a fertilizer if salt has not been added.

BONES

As the heat supplied for cooking the offals is insufficient to digest the bones, they separate out from the rest of the offal meat and give up their fat during cooking. The removal of fat is however incomplete. The bones recovered may be dried and burnt to make bone ash.

FUEL FOR COOKING

Dried stomach contents can be combined with fuel and burnt, thus saving some fuel expenses. In some units, the fire grating is separated into two decks and the cooked dried bones are piled on the upper deck. These also burn providing additional fuel and in the process turn into bone ash. At times bones and low grade horns are directly fed as fuel. The ash obtained in this case is rich in phosphates and also in potash contributed by burning wood and stomach contents.

DISADVANTAGES

The disadvantages of open kettle method are that the odours emitted during cooking are unacceptable and therefore the unit must be located well away from residential dwellings. Nearly 10-15 per cent of the weight of meal is lost as liquid stick and if the liquid stick contains a large amount of salt it does not serve as a fertilizer due to high salinity. The meal and tallow produced are of the poorest quality. The meal may not be palatable when used in stock feeds and thus, the meal is primarily useful as a fertilizer mix. The fat finds use for burning oil, lubricant or when further refined for use in production of low quality soaps.

In spite of these several disadvantages, this method, as stated earlier, will be a forerunner and provide sufficient experience to the rural folk. Rather than condemning the method as ludicrous, slow improvements and improvised contrivances adapted from locally available materials will go a long way in providing better returns and is to be prefered to the disposal of carcass by burial or incineration.

High temperature rendering methods

In open kettle rendering described above, the offals are cooked at the boiling temperature of water. Wet rendering, dry rendering and other processes described here operate at temperatures much higher than the boiling temperature of water. The higher boiling temperature is obtained by rendering at a higher pressure. The higher pressures attained in the cooking vessels used in these operations primarily aid in raising the boiling point of water commensurate with the pressure of operation (Table 6). The work done, or the energy supplied for rendering is essentially the higher thermal energy. This explanation is provided here, mainly to ward off any misconstruded opinion that steam pressure does the work on the process. In a closed container where the entire material is under one pressure, the concept of a pressure difference between the material (offal) and the container (rendering vessel) does not exist. The steam pressure read by the gauge is essentially the contained pressure in the chamber (rendering vessel) and the reading of this pressure is important only to the extent to correlate it to the temperature of operation. The pressure gauge also acts as a guide to operate within the safety limit, the vessel is designed to withstand. Certain rendering equipments and pressure vessels are fitted with a pyrometer as well as a pressure gauge so that the operating temperature important to rendering and the pressure (which can be equated to temperature of operation) which is important fo operating within safe working conditions are read.

TABLE 6

Temperature of pure steam versus pressure

Temperature°C	*Pressure as read on gauge* *Kg/cm²*	*psi*
108.8	1.4	20
116.3	1.8	25
119.6	2.0	30
126.5	2.5	35
132.8	3.0	40
138.8	3.5	50
142	4.0	55
147	4.5	65
151.9	5.0	75
158.0	6.0	85
161.7	6.5	95
164.2	7.0	105

It is unfortunate that most of the high steam temperature working processes are specified by the pressure of operation rather than by the actual temperature required. This could at times be imprecise as the pressure obtained by evaporation of water may not always correspond to the temperature under non-ideal conditions. Steam tables indicate the steam pressure versus temperature correlations for pure steam. Steam-air mixture and volatiles in the material rendered can considerably alter these ideal conditions to indicate the partial pressure of the system. In such a case, for example, 1 kg steam pressure may not correspond to 120°C but less as the pressure indicated is no longer that of pure steam. It is worthwhile to bear the above fact in mind, eventhough such stringent operating pressure and temperature control are not going to adversely affect rendering processes.

Wet rendering

Wet rendering or steam rendering is the method of choice for rendering edible offal products where colour, flavour and keeping qualities of fats are of prime importance and the relative yield of protein residue is small. The simplicity of operation of the wet rendering plant has however tempted its usage for rendering inedible offals as well. Wet rendering produces a fat of good quality and the residue (protein) is available from these plants as a liquid stick or tankage. Where the yield of residue is far larger in proportion to that of fats, the liquid stick is separately redried in steam jacketed vessels. Consequently the recovery of offal meal is at a relatively high cost and low efficiency.

Fig. 17 provides a lay out of the wet rendering system and Fig. 18 a flow chart of the process as generally practised.

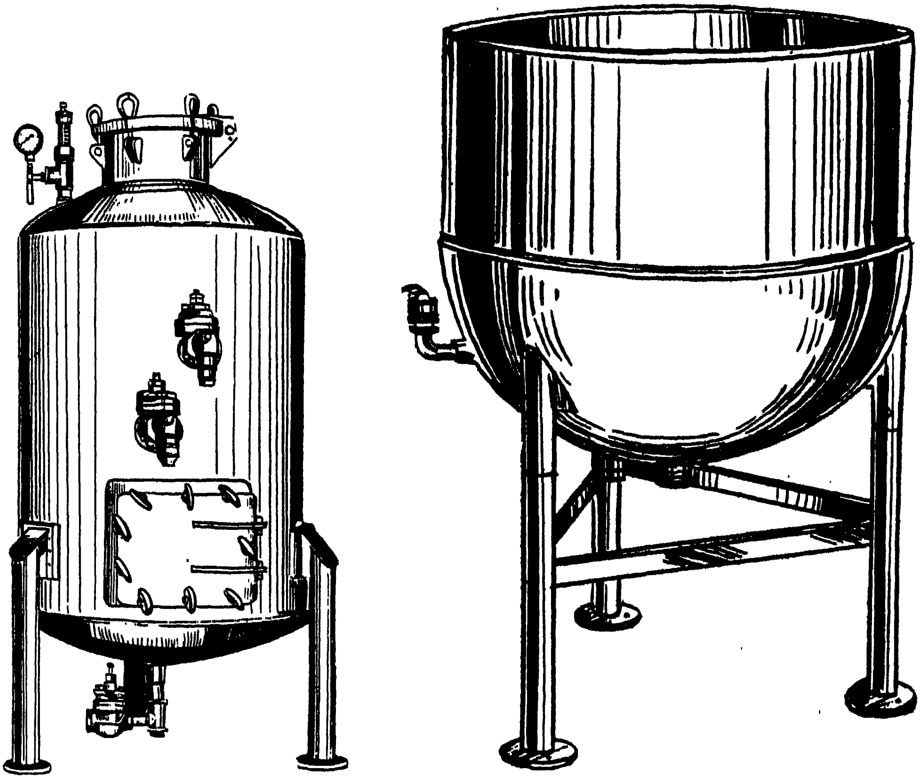

Fig 17 : The wet rendering pressure vessel (left) and the steam jacketed dryer (right).

Wet rendering is essentially an enlarged form of a domestic pressure cooker or a laboratory autoclave. In the wet renderer, the steam is generated either from the water held in the container itself or delivered from a boiler. The simplest form of wet rendering cooker consists of a pressure vessel (Fig. 17) sufficient in capacity to hold nearly twice the volume of the stock to be produced. The vessel has one or

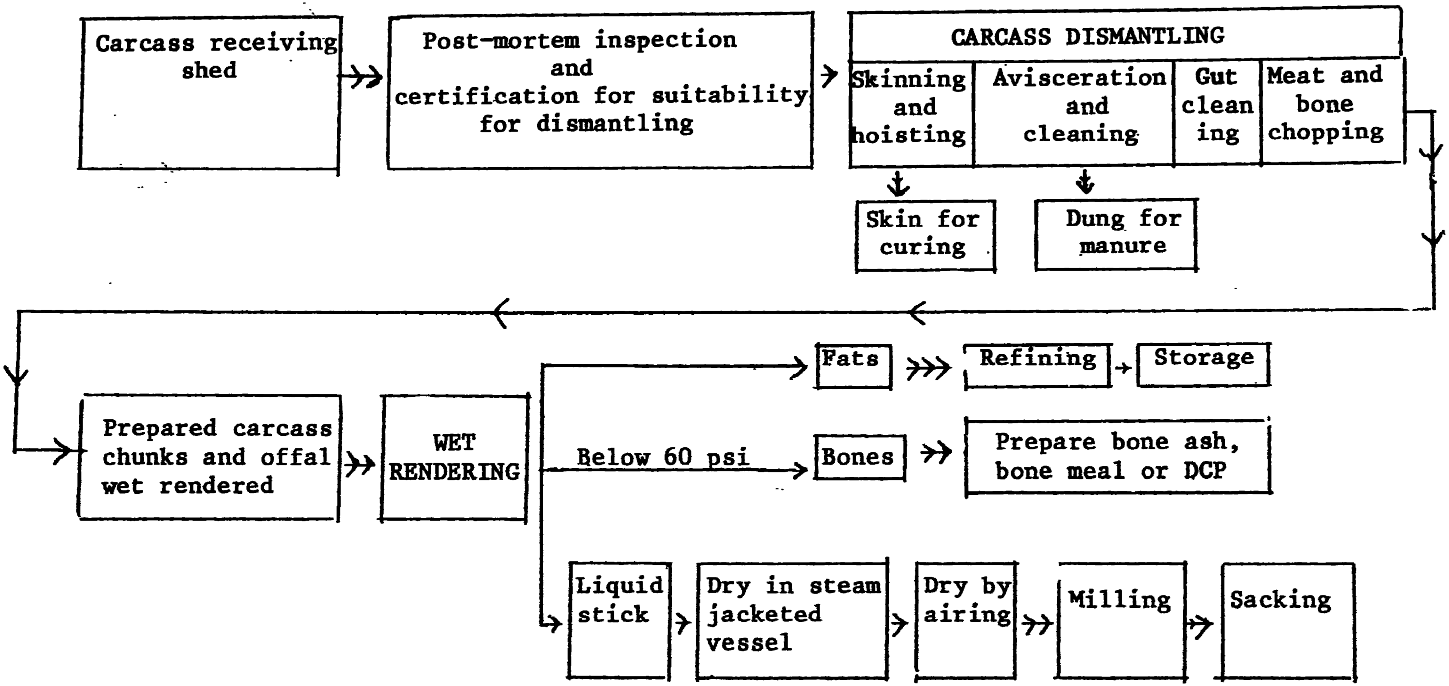

Figure 18. Flow chart of wet rendering operations

more cocks located at various depths through which oil can be drained after cooking. The stock is added to fill a maximum of three fourths the volume of the vessel and covered with just the sufficient amount of water to cover the stock. The steam-tight lid and the cocks are sealed and the vessel is heated. Any fuel—wood, coal, oil or electrical heating-may be used to provide heat. The control devices attached to the wet rendering vessels are air outlet valve, safety valve, pressure regulator, and a pressure gauge. After heating has commenced, the air outlet is kept open until the water boils for some time and drives out all the air displacing it with steam. This may take any time from 5 to 15 minutes depending on the size of the rendering vessel. This procedure helps to attain near ideal temperatures of steam under a known pressure. Steam-air mixture under pressure, unlike pure steam under the same pressure remains at a lower temperature and thus prolongs cooking time. After the air vent is closed, steam pressure begins to build up. The pressure is allowed to rise until 2.8-4.2 kg/cm^2 (40-60 psi) and maintained at that range for 3-4 hours. During this period, the entire contents would have been totally digested. The fats will separate as oil and being of a lower specific gravity than the rest of the digest (liquid stick) separate to form a layer on the top. As stated earlier, the formation of a layer of oil-in-water emulsion which still holds a lot of fat in emulsion is inevitable. At the end of the 3-4 hour digestion, the heating is cut off and the contents of the rendering vessel allowed to cool until the pressure gauge reads zero, indicating that the pressure inside the vessel is in equilibrium with atmospheric pressure. It is not advisable and at times even dangerous to open the cooker when it is under pressure. Any attempt to open the cooker even when the internal pressure is as low as 0.2-0.3 kg/cm^2 (3-5 psi) will throw up the lid and contents, due to the violent boiling caused by sudden exposure to lower pressure. Prior to opening the lid, it is always safe to open the air vent first (only after the pressure gauge reads zero) to allow some steam to escape or some air to be sucked in, the latter happening when the contents had cooled much below 100°C.

FATS

The upper layer of oil and emulsions can be drained out after some settling by opening the cock corresponding to these layers. This can be judged with the help of a dip stick. Addition of water to raise the height of the layers to just above the level of the cock aids in separation of more oil from the viscous liquid stick layer. At times, small chunks of solids migrate to the fat layer and block the free flow of oil (particularly when deboned material is rendered). To prevent this happening, it is always desirable to have straight tube outlets, with butterfly valve and a removable elbow, so that one can remove the elbow and push in the solids blocking the outlet. The oil drained out is refined further as described separately in this chapter.

LIQUID STICK

The liquid stick is drained out and dried to a 10 per cent moisture level in a steam jacketed vessel. There are other ways of drying the liquid stick. The liquid stick can be concentrated to 40 per cent solids content (assessed by previously determining the specific gravity of known or prepared 40 per cent solution) and then drum-dried. When drum-drying, the contact temperature on the drum is maintained at 90°-100°C and the temperature is maintained generally by steam heating. The dried material is crushed and seived to the desired mesh size (usually 10 or 20) for use in feed mix or fertilizer mix (see also wet rendering of fish offals for alternate techniques in chapter 9).

HEATING FOR WET RENDERING

Wet rendering described above depends on the generation of steam from the water contained in the vessel. When a boiler steam supply is used, the steam is injected from the bottom of the pressure vessel. The injection of steam also agitates the contained offals and consequently hastens the time of operation. The liquid stick obtained by injecting steam will be more syrupy (concentrated) as the total water condensed at the end of the operation is considerably less, than when water is used directly as a medium for heating. The use of a boiler for heating also facilitates using a steam jacketed vessel for concentrating or drying the liquid stick as described earlier.

Dry rendering

Dry rendering is the method of choice for carcass offal products, as the avilability of protein residue and its recovery is the prime need, than recovery of fat. The process cost in dry rendering is lower than in wet rendering, when a larger quantity of offal materials are available. In the case of offals, where the yield of tallow is high compared to protein residue, it is possible to obtain a tallow of quality equal to that obtained by wet rendering. Protein quality being superior and operational costs being decidedly lower, dry rendering should be the method of choice for large scale (one ton or more offals per operation) carcass rendering.

Commercially available dry rendering units have capacities from 1 to over 50 tons. These units are invariably equipped with mechanical agitator, which turns the offals constantly inside the rendering chamber.

The principle of dry rendering can be summarised as follows :

1. Rendering is done in a sealed pressure vessel.
2. Rendering is done without the addition of any water. The water needed for cooking is obtained by the evaporation of the moisture contained in the offals
3. Heat for rendering is supplied by steam, held in a jacket surrounding the vessel in which the offals are loaded. The steam supplied from the boiler to the jacket does not therefore come into contact with the offals.
4. The offals in the contained vessel are preferably stirred. Stirring prevents adhesion of offals to the cooker wall, increases the surface area of contact for heating the offals and accomplishes faster heating at a more uniform rate

COST CONSIDERATIONS

The capital investments for setting up a dry rendering plant are invariably high. A hasher-cum-washer machine which cleans and reduces the size of offal material is essential as most dry rendering units are fitted with an agitator. Large bones delivered into the cooker can cause extensive damage to the agitator. Reducing the size of the bones manually is difficult, time consuming and contributes to the reduction in hygienic standards. The dry rendering system (Fig 19) consists of a Hasher-washer machine, a dry renderer, and a hydraulic or screw press for expelling fat. In addition to these, the rendering unit has a boiler, conveying systems like screw conveyer, fat clarification units and other accessories. The list enumerated certainly calls for a rather heavy capital investment.

OPERATIONS

Hasher-washer operation

The prepared carcass material is hashed and washed. The hasher reduces the size of the material to suitable sizes for charging into the renderer. Washing helps to obtain a clean charge. The digestive tract and organs are not hashed, but only washed manually for the charge. In large installations, a tripe washing machine may be installed, but its need in a carcass utilization plant is only secondary.

Charging the cooker

The hashed and washed offals are transferred into perforated drums prior to charge, to drain out the water to the maximum extent possible. The rendering unit is started and jacket steam pressure is maintained at 0.7-1.0 kg/cm^2 (10-15 psi) before the charge is commenced. The agitator which rotates at 20 to 40 rpm is also started. The offal charge is loaded usually to fill half to three fourths (never more) of the capacity of the cooker vessel.

Ratio of bone to offal

An ideal charge can have 60 per cent offals and 40 per cent bones. Whole carcass materials as loaded in carcass centres provide 25-40 per cent bones and 75-60 per cent offals. The presence of bones in the cooker offers certain advantages. Bones mixed with other material scour the inner jacket surface and aid the agitator in mixing the charge and prevent initial adhesions on the cooker surface. This consequently reduces cooking time. As much as 40 to 50 per cent of bones in the charge can thus be used with advantage. The cooker, after the charging, is closed.

Steam pressure

The air vent is kept open and the jacket steam pressure is raised gradually to 5.0-6.5 kg/cm^2 (70-90 psi). This gives an internal cooker pressure of 1.75-3.0 kg/cm^2 (25-40 psi). The agitator is worked throughout the process. The air vent is usually

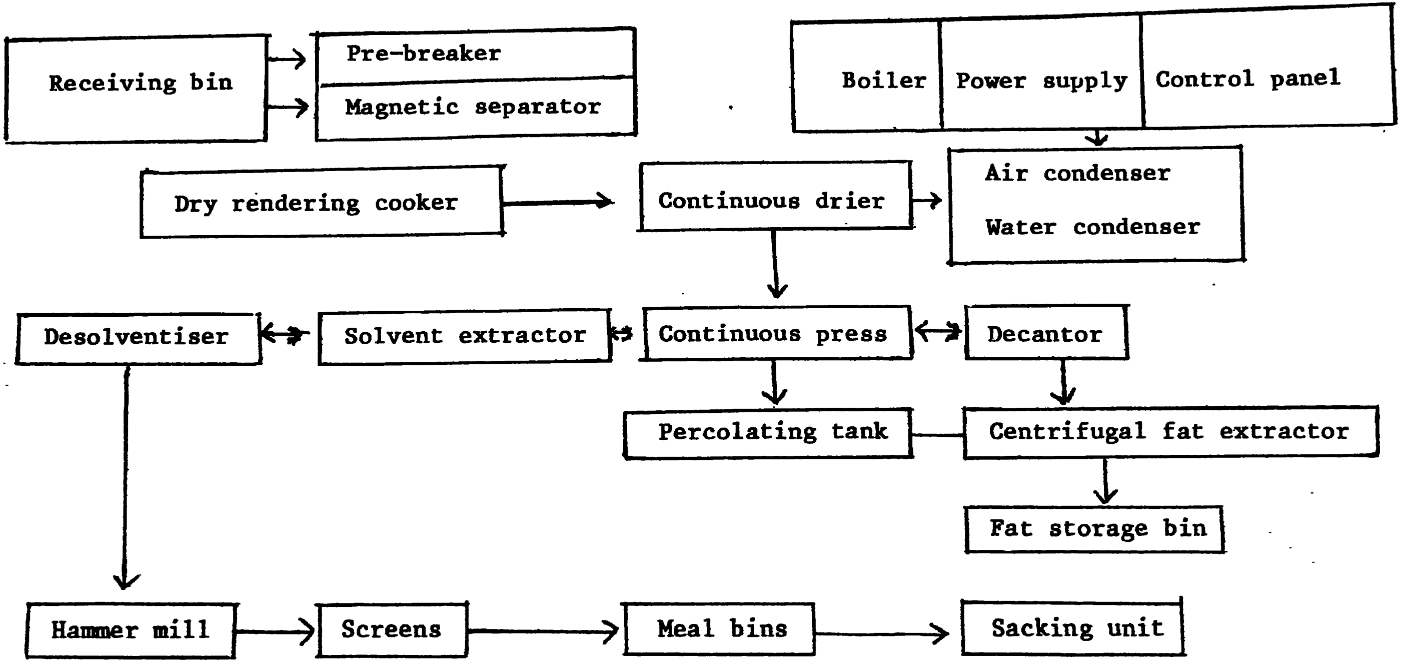

Figure 19. Flow diagram of a large scale continuous dry rendering system

regulated so that the pressure inside the jacket is maintained at 1.75-3 kg/cm^2 (25-40 psi) and the excess steam generated escapes constantly after passing through a trap. The trap eliminates the cooking odours from fouling the air in the surroundings. The cooking time ranges from 90 minutes to 4 hours in an efficient cooker and may be as long as 8 hours under low efficiency operation or in large cookers handling heavy operating loads.

Sampling

Many dry renderers have provision for obtaining samples of the cook while rendering is in progress. This facility is of utmost importance when processing offals for obtaining tallow of high quality. In carcass rendering operations, after some experience it may be necessary to examine samples to evaluate if rendering operation is properly carried out. The evaluation is done by examination of the cook, tallow and final products (the meal and refined tallow).

Stages in the cook

During the rendering process, the material can be assessed to pass through three main stages :

1. *Glue stage :* The cook feels gluey and at this stage the fat has not been totally expelled.
2. *Moist sandy stage :* The fat has been released, but a large amount of moisture is still present.
3. *Dry sandy stage :* This is the end point when the moisture has also been explled. The product feels sandy.

The percentage of moisture retained is dependent on the temperature and duration of cook and a proper assessment of the end point is only obtained by experience. The moisture content of 4-8 per cent in the end product is decidedly advantageous.

Separation of tallow

After the cooking is completed by bringing the product to a dry sandy stage, the next operation is separation and recovery of tallow. The molten fat if already separated and found in larger quantity is drained out and collected. The separation of fat from the dry tankage is done by the use of hydraulic press or screw press. In either case it is important to note that fat should be separated much before the tankage gets cold and preferably at 80°C (180°F) as cold pressing leaves more fat in the pressed cake. In normal practice, the tankage with the molten fat is transferred to a perforated container to percolate as much fat as possible and later pressed to recover the held fat. The operation should aim at separation and recovery of maximum amount of fat.

The technique and control adopted during rendering tell on the separation of fat and its quality. For example, over cooking leaves a large amount of fines in the fat. Overloading the unit leads to the same problem and leaves a tankage of lower moisture and high fat content. Undercooking causes difficulties in pressing as the gluey material tries to escape through the vents in the press and mix with the fat. Thus a press cake of high moisture and fat content and low fat yield will be the result.

Properly proportioned cook and offals cooked to the correct degree result in a good yield of clear fat and the press cake will hardly need any further processing before being sold for compounding to feed mixing plants.

The dry rendering operations described as above are necessarily brief. The operation when executed in actual practice requires far too many steps and precautions. For example, the time of operation of agitator, opening of steam valves, operating pressures, inlet and outlet jacket steam pressures, etc., are critical. Specific operating instructions in the form of a published manual or personal assistance is generally provided by suppliers of these plants. Their instructions should be scrupulously adhered to. These specific instructions vary greatly from one manufacturer to another that these are difficult to outline here.

Improving Fat Quality

The term improving fat quality has been chosen in preference to the term clarification of fat as the latter may be difficult to achieve when the offals are of miscellaneous variety. The description given here on improving fat quality applies to all varieties of fat obtained, viz., open kettle rendering, wet rendering and dry rendering. Depending on the initial fat quality, certain operations should be included or deleted.

Process for improvement of fat quality begins, the moment the fat has been separated. Taking hot melted fat to commence the operation is better than remelting solidified fat.

FACTORS DETRIMENTAL TO FAT QUALITY

Heating is the first detrimental factor and especially when heating is done in open containers. Heating enhances the free fatty acid (FFA) content and free exposure to air promotes oxidative rancidity. This is one reason why open kettle rendering yields a fat of poorest quality. Over heating of fats also results in darker colour in fats and lowering of bleachability. In the case of wet rendering and dry rendering processes, these factors apply equally well. Heating caused beyond 145°C (3.3 kg/cm^2 or 47 psi) increases the FFA content considerably for every degree rise in temperature. The pressure rendering operations should therefore restrict rendering to a cooker chamber pressure of 2.8 kg/cm (40 psi) in order to minimise degenerative changes in recovered fat.

FILTRATION

The fat is first brought to a temperature of 85°—95°C (190°—200°F). The molten oil can be filtered if found to contain recognizable coarse particles, insoluble debris, stones and leaves. Filtration is best done using a filter cloth or a double layer of knitted hessian. Filtration step may be omitted if fats are dry or wet rendered.

SETTLING

Settling is the best method of eliminating moisture and fine suspended matter. A properly rendered fat settles rapidly. The fat is maintained in liquid form by heating preferably by steam coils or any other indirect heat source at 85°—95°C (190°—200°F) for a few hours. The fines and the water settle at the bottom and some moisture may escape by evaporation. The heated fat should settle for a minimum of 6-8 hours. The water layer containing fines is drawn off by a cock at the bottom or alternatively the fat layer is drawn off by cocks located at a height above the water layer. The latter operation is more difficult to judge. Settling equipments are commercially available and these can also be easily fabricated with locally available materials.

WASHING FATS

Washing refers to the removal of solids held in emulsion in fats by physical or chemical treatments. The solids held are largely proteins and they are separated by coagulating them. The coagulation of proteins in suspension increases their particle size whenceforth they can no more maintain an emulsion state and settling results.

STEAM OR WATER WASH

The simplest method of washing is to purge steam to coagulate the proteins. Hot water can be added to bring the final temperature to about 70°C (160°F). Settling takes place after a few hours and the fat becomes more refined.

SALT WASHING

Washing can be done with a solution of 3 per cent salt (sodium chloride) or 0.03 to 0.1 per cent citric acid or 10 per cent tri-sodium phosphate. The hot solution of any one of the above at 100°C (212°F) is added to the molten fat and maintained at that temperature until settling is complete. The quantity of salt solution added and the time required for settling are predetermined by experimenting with 500 ml of fat taken in a tall glass beaker or cylinder and noting the settling behaviour and time taken. In order to obtain a highly refined fat, the water or steam wash is followed by washing with each of these chemicals separately in that order and finally finishing with one or two water washes to remove any free salt.

Centrifugal cleaning and solvent refining are some of the other methods used but these methods are usually adopted by the user who determines the degree of refining required on the purchased fat.

Other rendering methods

Heat is an enemy to fat quality, a point that has been stressed earlier. Many other rendering methods have been evolved where the heat of operation is kept to minimum to obtain higher quality fat. These methods are intended for offal products with high fat content, where the recovery of protein residue is of secondary importance. Brief descriptions of some of these processes are given below.

LOWRY CIRCULATING RENDERING

This is one of the vacuum rendering techniques wherein low indirect steam temperatures are used to conserve the quality of tallow. This method attempts to enhance heat transfer efficiency. This is achieved by rapidly circulating the cooker contents and by priming the cook with additional tallow. The added tallow makes a more fluid mass to be fed rapidly into the cooking vessel.

KINGAM CONTINUOUS RENDERING

This rendering method is applicable to raw fat with very little protein residue and no bones in the cook. The material is ground mechanically and pumped through a rotator or other types of heat exchangers and reground in a hammer mill. Separation of the rendered fat, water and protein residue is then effected by a Nozzlematic centrifuge. The wet protein residue is either discharged or processed further by dry rendering.

CHAYEN 'IMPULSE' RENDERING

The process is essentially applicable for separation of fat from ground bones and has not found wide application for meat offals. Rendering is accomplished by sonnication or high frequency pulses of a violent nature, generated by a series of freely swinging hammer bars attached to a spindle. The material fed with around nine times its volume of water through a hopper is obtained after sonnication as a water-in-oil emulsion and fat-free solids. Further processing includes a series of centrifuges and hot and cold treatments. The fat recovered by this method is of high quality as it has been heated only to the minimum extent required. The process is too complex for general applicability, especially for small scale operation.

VIO-BIN AZEOTROPIC RENDERING

The vio-bin azeotropic rendering is a low temperature process applicable to materials of animal and vegetable origin. Azeotropic rendering depends on the partial vapour pressure of a solvent and water system. For example, the solvent heptane, boiling as a pure component at 90°C (192°F) in contact with water, boils at 80°C (176°F). This solvent, during evaporation, carries away water vapour in the stream, thus removing water. The system is rather uneconomical for routine rendering as heat input to removal of water is at a low efficiency. Evaporation of 6.5 kg of heptane will be necessary to remove 1 kg of water.

In this system, after removal of water, the solvent is percolated and removed and the protein residue extracted sufficiently for complete removal of fat. The residue obtained in the end is almost free from fat. The solvent holding the fat in solution is evaporated off and the fat further refined by methods described earlier. This process will be ideally suited for processing catch basin residues or other offals where the protein content is very low and the offal is largely available as a slurry.

DRY MELTER—STEAM TUBE DRYER PROCESS

This is a modified dry rendering process designed to increase the capacity of the dry rendering unit. The molten fat from dry renderer is drained off after initial melting and the greasy residue is further dried in a steam tube dryer. The dehydrated material from this dryer is returned to the dry renderer to be processed by conventional operation.

CENTRIFUGAL RENDERING

In the De Laval centriflow process, the cell rupture is accomplished by mechanical disintegration at a lower temperature in a specially designed disintegrator followed by high speed centrifugal separation. The Sharples process employs a two stage centrifugation of the material that has been previously worked mechanically to rupture fat cells. The centrifugal methods score a distinct advantage for the production of high quality edible fats without loss of vitamins or their precursors contained in them. Centrifugal processes are applicable to edible fat processing.

ENZYME RENDERING

The raw offals are compacted to a very fine state in meat grinders and subjected to the action of proteolytic enzymes in stirred, temperature controlled hoppers. The enzyme hydrolyses the proteins and the hydrolysate is then rendered by conventional means to recover the fat, the protein residue finally being available as a peptone depending on the degree of hydrolysis.

MISCELLANEOUS METHODS

Low pressure system, Titan expulsion system, Pavia heater roller process are other rendering systems developed for recovery of fat and protein residue from offals.

ALKALI RENDERING

Alkali rendering technique was evolved essentially to recover fat of higher quality and to retain the potency of fat soluble vitamins and their precursors contained in them. Fish oils have a high content of vitamin A and vitamin of group D for which they are valued. Heat rendering processes do not effectively preserve their potency. Fish livers are minced to a fine paste and blended with caustic soda (1 per cent by weight), a mixture of calcium hydroxide and sodium carbonate (1-2 per cent by weight), and heated below 100°C. The proteins coagulate, undergo mild hydrolysis and the fats are liberated. The total recovery of fat by this method is higher than by most other methods (with the exception of solvent extraction). This method of rendering has found favour for recovery of fish oils on a large scale and large trawlers with built-in alkali rendering units have been in use.

The alkali rendering technique as such is not new, but its application to animal offal processing is a recent one. The system works ideally for fat recovery but much remains to be said about protein residue. Usually common salt is mixed with alkali and this has been of a definite advantage in improving fat recovery. The protein residues recovered after extraction of fats and neutralization contain salts derived from added salt and that from chemical conversion of alkali to its salt. The salts consequently add up to the ash content of meat meals produced to an undesirable extent and ash constituted of high salt content is undesirable. Alkali rendering can also alter the amino acid composition and lead to the formation of certain toxic compounds like lysylalanine. However, the toxicity of lysylalanine formed has been questioned recently.

The method has a great promise in future if some of the problems like high salt content and the formation of toxic products could be overcome. The advantages then would be:

1. If meat and bones are together alkali rendered, it will be possible to obtain defatted bones. The bones can also be easily separated.
2. The temperature of operation being 100°C or below, it dispenses with the use of pressure vessels.
3. In spite of low temperature used for rendering, the likelihood of pathogenic bacteria surviving alkali treatment are remote. Consequently, the meal produced will be safe for livestock feed compounding.
4. The method could very well fit in for rural technology.

It has been found through experiments (in the Central Leather Research Institute Madras), that offals, meats as well as blood, when stored in a solution of 5 per sent sodium hydroxide (based on weight of offals or blood) could store for periods as long as three months without showing any signs of putrefaction. This could be a great advantage as these materials can be collected and stored at room temperature with alkali and dispensing with the expensive refrigeration storage. But methods to recover protein residue of high quality, low salt content, reasonable yields and the recovery of fats require further investigation.

CHAPTER—VIII

Quality Evaluation of Rendered Products

Quality evaluation helps to understand and control production to meet consumer needs. A carcass centre may not be in a position to manufacture meat-cum-bone meal or fat of the same quality all the time. As explained earlier, the raw stock varies widely from batch to batch and the variations will be reflected in the end product. This does not obviously mean that a rendering unit processing carcasses can do away with quality evaluation. The products made should necessarily fall in a defined category so as not to restrict their marketing avenues. Batch to batch quality evaluation can also offer certain directions in suitably blending them to derive an uniform end product.

In this chapter, a brief account of the different tests performed to evaluate the quality of meat-cum-bone meal and fat is furnished, along with a discussion of the merits and de-merits of each method.

Methods of assessment of feed value of offal meal proteins

As one reads through the foregoing account, one may be lead to conclude that there is no single, specific, ultimate or exact method available to assess the quality and suitability of meat-cum-bone meal protein for feed supplement. This is true. This handicap is bound to exist, as it is practically impossible to totally reproduce conditions that exist in the natural digestive process, especially when the feed is a complex array of materials, which interact to catalyse or nullify the digestion, absorption or metabolism of individual ingredients. To give some examples, the amount of calcium estimated by chemical analysis in a sample does not necessarily correspond to the calcium made biologically available to the animal in the feed. Calcium can form salts with stearic acid and adsorption of calcium from calcium stearate is only 25 per cent compared to absorption of 90 per cent from calcium oleate. Similarly, phytic acid from injested plant materials can considerably influence the absorption of calcium, phosphorus, magnesium and zinc, which form insoluble complexes as phytates and will not be available to the system in the absence of a phytase. Similarly, two offal meals can have an identical 'crude protein' (nitrogen content x 6.25) content but one may be considerably inferior to the other in actual feed value. This is so, as chemically estimated crude protein is not directly correlated to protein available for enzymic digestion in the animal.

The situations to be elaborated in the present methods are much simpler, as the evaluation will primarily relate to their utility for simple stomached animals like pigs and polutry. The proteins fed to the animal are ultimately broken down by proteolytic enzymes in the stomach and intestines of these animals into amino acids and absorbed. The amino acids are broadly divided as essential amino acids, which must be present in diets (for example, lysine, methionine, etc). The non-essential amino acids are primarily those that need not be supplemented in the diets as these will be synthesized by the animal that receive a balanced feed ration. But the latter should also be present in the diet to meet the metabolic needs of the animal. In the case of ruminants like cattle and sheep, the materials finally avilable for absorption from the alimentary canal are vastly different from those made available in the feed. The rich microbial flora in their rumen utilize carbohydrates in the feed as their energy source and synthesize most of the amino acids to meet the protein requirements of the animal. Thus the need for intake of dietary proteins is minimal and this is one reason why they do not require supplementation with meat based meals in their feed. There are also other considerations like palatability (for example., ruminants do not relish high protein content in feeds). The question of palatability cannot be taken lightly when compounding rations for simple stomached animals as well.

Proteins

It will be seen from Table 4 (chapter 4) that meat-cum-bone meal contains 50 per cent protein, 9.5 per cent fat, 10 per cent moisture, 3 per cent fiber, 14 per cent pepsin indigestible residue, 9 per cent calcium and 4.5 per cent phosphorus.

CRUDE PROTEIN

The crude protein in food is calculated from its nitrogen content. Nitrogen content is determined by Kjeldahl method (Appendix I) with necessary modifications. In calculating Crude Protein (CP) from total nitrogen content, two assumptions are made: (i) all food proteins contain 16 per cent nitrogen and (ii) all the nitrogen estimated is present only as protein. Based on the above two assumptions the crude protein content is derived as follows:

$$\text{Percentage CP} = (\text{Per cent N} \times 100) / 16 = \text{Per cent N} \times 6.25$$

The reliability of this method is based on the two assumptions stated above, both of which are questionable. Tha factor 6.25 is largely in error and it is too much to rely on the assumption that all the nitrogen estimated is present only as protein. The offal meal will contain several nitrogenous compounds such as amides, free amino acids, glycocides and ammonium salts which are not true proteins. This method would be logical if animal protein requirements are specified only in terms of nitrogen.

TRUE PROTEIN

Determination of True Protein (TP) is done by coagulating the proteins by cupric hydroxide or by heat coagulation and determining the nitrogen content of the residue. In this method, the added nitrogen value obtained by non-protein nitrogen is eliminated.

DIGESTIBLE CRUDE PROTEIN

The determination of CP or TP content does not give an indication of how much nitrogen is useful to the animal. Digestible crude protein is estimated by incubating the material with acid pepsin at 37°C for 48 hours. The residue after digestion is estimated for nitrogen and subtracted from the total equivalent amount of nitrogen initially subjected to digestion. The reliability of this method is again questionable. The digestion is done with only one kind of proteolytic enzyme, namely pepsin, whereas a host of enzymes are involved in actual digestion in the alimentary canal. The technique of grinding the protein alters the *in vitro* digestion and one therefore obtains variable results. At best, this method can offer values for comparison of several samples.

EVALUATION OF PROTEIN FOR SIMPLE STOMACHED ANIMAL

Protein Efficiency Ratio (PER)

The method is based on feeding experiments in rats. The protein at 10 per cent level in the diet is fed to a group of male rats for a period of four weeks. casein, a milk protein, is at times used to feed a second group of rats as controls. The PER is calculated by dividing the gain in body weight in grams (numerator) by the protein consumed in grams (denominator).

Gross Protein Value

Three groups of chicks are fed ; group I receiving a basal diet containing 8 per cent protein, group II receiving the basal diet plus additional 3 per cent test protein and group III receiving basal diet plus 3 per cent casein instead of test protein. The Gross Protein Value (GPV) is calculated as follows :

$$\text{GPV} = \frac{\text{Weight gain of group II} - \text{Weight gain of group I}}{\text{Grams of test protein}}$$

$$\times \frac{\text{Grams of casein}}{\text{Weight gain of group III} \quad \text{Weight gain of group I}}$$

The evaluation of protein quality by PER and GPV requires a regular supply of experimental animals of defined sex, age and body weight and facilities to maintain them under controlled environment (temperature, humidity, and diurnal rythms). Greater accuracy could be obtained in these experiments by evaluating nitrogen balance taking food nitrogen, fecal nitrogen, urinary nitrogen and nitrogen retained in the body into consideration.

Protein Replacement Value (PRV)

This is an elaboration of the nitrogen balance estimation by determining the extent to which the test protein and a standard protein will give the same nitrogen balance. By determining PRV, one can obtain an idea of the efficiency of utilization of the protein tested on the animal.

Biological Value

The utilization of proteins taken from food by the animal is through their breakdown into amino acids by the process of enzymic digestion in the alimentary canal. The closer the amino acid composition of the food protein is to the amino acid composition of animal protein, the nearer they approach in biological value. Animals have little ability to store amino acids for future protein synthesis, unlike their metabolic capability to store fats and carbohydrates. Thus, excessive proteins fed to the animal are broken down and the essential amino acids not required at that moment are either converted to non-essential amino acids needed by the animal or used as energy source or excreted. Since the essential amino acids cannot be synthesized, these should be and must be provided in proper proportions in animal feed and while their deficiency lowers the growth and productivity of the animals their presence in excess is an economic loss. One method adapted for evaluation of biological value of proteins is by conducting actual feeding trials and correlating the nitrogen (N) intake and excretion. The Biological Value (BV) in this case is calculated by applying the formula,

$$BV = \frac{\text{N Intake} - (\text{fecal N} + \text{urinary N})}{\text{N intake} - \text{fecal N}} \times 100$$

This formula does not take into consideration the metabolic fecal nitrogen not directly derived from food. Thus further refinements are applied to correct several drawbacks, but suffice it to say that the estimation of BV provides a more direct approach to evaluation of proteins. For example, it was found that meat and bone meal showed a true digestibility of 86 per cent compared to 95 per cent for whole egg protein. The lower biological value of meat and bone meal for poultry feed is probably associated with the high level of ash present. Actual feed trials are complex in that they require an extensive array of laboratory facilities and a constant supply of animals. Certain direct chemical analytical procedures or alternatives to actual feed experiments are consequently adapted in protein evaluation.

CHEMICAL ANALYSIS

Amino Acid Analysis

The biological value of a protein is primarily dependent on the amino acid composition and consequently it seems logical that an analysis of amino acids present will be of value. Methods are available to estimate the total amino acid content of proteins. The automated amino acid analyser can be used for this purpose. The accurate resolution of amino acid composition of a protein does have considerable technical difficulties and the technique and apparatus are rather expensive. Acid hydrolysis used to hydrolyse the protein destroys particularly all the tryptophan and a large part of methionine and cystine present in the protein. Alkali hydrolysis is used to estimate these components separately.

The total amino acid content generally gives a false indication of the biological value of proteins as a proportion of amino acids tested by this method are never released in the process of biological digestion in the animal and therefore unavailable for metabolic use. Antitryptic factors present in considerable quantities in proteins also complicate accurate evaluation of biological activity.

ESSENTIAL AMINO ACIDS

The presence of essential amino acids in the feed composition and their biological availability to the animal are the deciding factors in assessing the value of a protein. The FAO Recommended Reference Amino Acid Pattern, using egg protein as standard is one of the methods followed. For example, egg protein contains 7.2 per cent lysine and blood meal (heat treated) contains 4 per cent lysine. The *Chemical score* for blood protein will then be $(4/7.2) \times 100 = 55$. But such values are not of general applicability in estimating the biological values of feeds for different animals.

Essential Amino Acid Index

Essential amino acid index (EAAI) is a geometric mean of the egg protein ratio of ten essential amino acids to that of the protein being evaluated. EAAI can be used for predicting the value of supplementation with a combination of proteins, but fails when evaluating single proteins with varied amino acid composition. The index may be high but the content of the non-essential amino acids for metabolic needs could be considerably low in certain cases.

Microbiological Assays

Microbiological assays have been used to measure the availability of some amino acids. The availability of lysine and methionine have been measured using the organism *Tetrahymena pyriformis*. Similarly, *Streptococcus zymogus* has been used in other assays. The microbial assays are complex and the results need to be assessed with caution.

Available Lysine Value (ALV)

Lysine is an essential amino acid for all species of livestock. Therefore the estimation of biologically available lysine alone could be used with advantage to assess the value of a protein. The chemical estimation of lysine proposed by Carpenter (with modifications for proteins from different sources) is now firmly established as a routine chemical procedure widely used in commercial organisations, compounding feed rations. The method (Appendix II) relies on the reduction of 1-Fluro-2-4-dinitro-benzene (FDNB) with the unbound *Epsilon* amino group of lysine and gives a measure of the proportion of the total lysine which is available for the metabolic process in the animal. When an amino acid analysis is done the chemically estimated lysine is not entirely equal to the estimated value of biologically available lysine.

MEASUREMENT OF PROTEIN QUALITY IN RUMINANTS

The rendered offal meal seldom forms a part of ruminant rations, except in calf starter rations, for reasons of palatability and the natural microbial symbiotic protein availability. Thus, only a brief account of the measurement of protein quality for ruminants is given here. Protein intake by ruminants is confined to the low protein containing roughages such as hay, grass, straw, silage. The protein metabolism in ruminants is complicated by the fact that the rumen itself can be considered a protein factory synthesizing bacterial and protozoal proteins, that are later made available to the animal. The digestibility of microbial proteins in their intestines is well over 75 per cent. Feeding proteins to the animal may not impart special benefits, as these will be rapidly deaminated to produce ammonia and finally excreted as urea. Complex metabolic experiments are needed to evaluate protein value in ruminants. A regression coefficient applicable for Digestible Crude Protein (DCP) can be used for this purpose.

$$\text{Per cent DCP} = (\text{Per cent CP} \times 0.9115) - 3.67$$

Where CP is crude protein and the factors are standard numerical values obtained by extensive experimentation by feed trials. This value applies well for grass, hays and silages.

Commercially Applicable Methods For Assessment Of Feed Value Of Offal Meal Proteins

MEAT AND BONE MEAL

Fig. 20 summarizes the several tests for quality usually followed for the assessment of rendered meat and bone meal. A rendering unit processing carcass may not have the facilities for quality evaluation by most of the methods discussed. An estimate of the percentage of moisture, fat, ash and nitrogen will suffice to fix a price for the rendered product in the marketing channels. The other methods

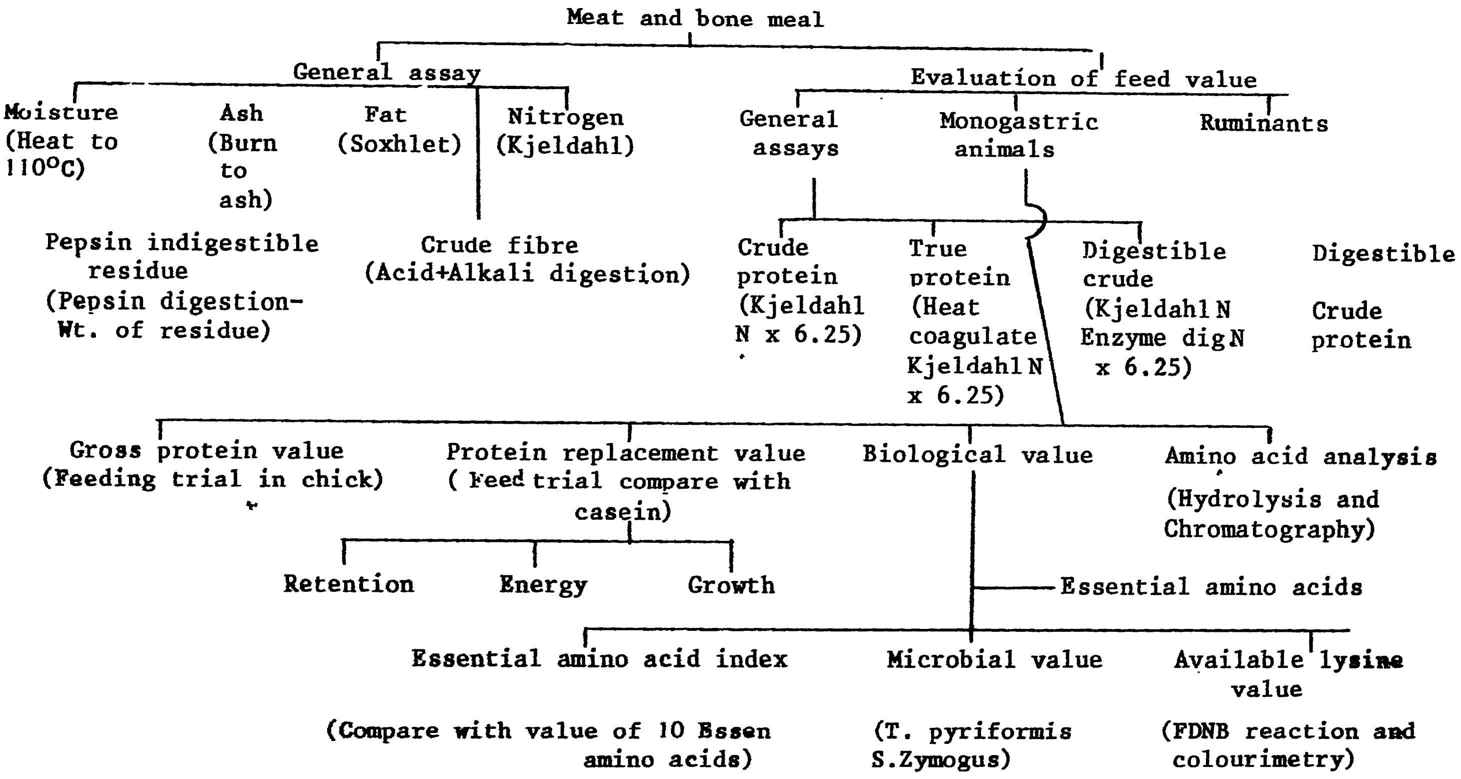
Meat and bone meal
General assay
Moisture (Heat to 110°C)
Ash (Burn to ash)
Fat (Soxhlet)
Nitrogen (Kjeldahl)
Pepsin indigestible residue (Pepsin digestion-Wt. of residue)
Crude fibre (Acid+Alkali digestion)
Evaluation of feed value
General assays
Monogastric animals
Ruminants
Crude protein (Kjeldahl N x 6.25)
True protein (Heat coagulate Kjeldahl N x 6.25)
Digestible crude (Kjeldahl N Enzyme dig N x 6.25)
Digestible
Crude protein
Gross protein value (Feeding trial in chick)
Protein replacement value (Feed trial compare with casein)
Retention
Energy
Growth
Biological value
Amino acid analysis (Hydrolysis and Chromatography)
Essential amino acids
Essential amino acid index
(Compare with value of 10 Essen amino acids)
Microbial value
(T. pyriformis S.Zymogus)
Available lysine value
(FDNB reaction and colourimetry)

Figure 20. Summary of tests for quantity evaluation applied to rendered offal meal

used for assessing the feed values of offal meal proteins are intended to provide a clearer understanding of the problems and prospects in actual feed requirements of animals. This information, albeit not directly applicable to the renderer, spells out the ultimate goal in manufacturing what is practically needed.

ESTIMATION OF MOISTURE, FAT, ASH AND NITROGEN

Moisture

Moisture is not a nutrient constituent of the offal meal. It is determined by heating a known weight of the offal meal to remove moisture (heated in an oven at 105°C for 90 minutes, cooled in a desiccator for 20 minutes and weighed). The difference between the weight of sample taken and the heated moisture-free sample is obtained to calculate the percentage of moisture.

$$\text{Per cent moisture} = \frac{\text{Weight of material taken (g)} - \text{Weight of heated sample (g)}}{\text{Weight of material taken (g)}} \times 100$$

Determination of moisture is of utmost importance as the percentage of fat, ash, and nitrogen are generally expressed on a moisture-free basis (see also Water Activity in chapter 10)

Fat

A known quantity of the meat-cum-bone meal is extracted in a Soxhlet apparatus using a suitable solvent (chloroform or petroleum ether). The fat-free meat is taken for further analysis. The solvent is evaporated off and the fat is weighed to calculate the percentage of fat contained in the meal (see Appendix III for details).

Ash

A portion of the fat-free meal obtained after the extraction of fat is ashed in a muffle furnace and the weight of ash is used to determine the per cent ash in the meal (See Appendix IV for details).

Nitrogen

A known weiget of fat-free protein is taken for the estimation of nitrogen by the Kjeldahl method which depends on converting the contained nitrogen into ammonium sulphate and estimating the liberated ammonia from the ammonium sulphate by back titration with acid of known normality. The actual nitrogen content is then determined after deduction of moisture, fat and ash in the original offal meal (see Appendix I for details).

Unit nitrogen value

The offal meal is sold on the basis of nitrogen value to the feed manufacturer. The same value is useful if the offal meal is sold as a nitrogenous fertilizer supplement. One unit of nitrogen is equal to 1 kilogram of nitrogen. Thus, if the offal meal contains 13 per cent nitrogen, a ton of the offal meal will contain 130 kg of nitrogen or 130 units of nitrogen. The price per unit cf nitrogen determines the price of the offal meal. This evaluation is based on the assumption that all the nitrogen in the offal meal is nitrogen estimated or derived entirely from proteins.

A typical analysis of a meat-cum-bone meal is given in Table 7.

TABLE 7

Analysis of a random sample of meat-cum-bone meal

Constituent	*Per cent* (on moisture free basis)
Moisture	10
Fat	9.5
Ash	20
Nitrogen	8
Crude protein (nitrogen × 6.25)	50

NRA SPECIFICATIONS

The National Renderers Association (NRA) provides specifications for several animal by-products and the specification by NRA for meat-cum-bone meal is reproduced in Table 8.

TABLE 8

Typical specification for meat-cum-bone meal

Constituent	*Per cent*
Protein	50
Fat	8-11
Fibre (maximum)	3
Phosphorus (P)	4.4—5.0
Calcium (twice P)	8.8—10
Ash (less than P × 6.5) (maximum)	28.6—32.5
Moisture (maximum)	10
Pepsin indigestible residue (maximum)	14

FIBER

Taken sufficient care to avoid contamination with stomach contents, crude fiber content will normally be lower than 3 per cent. Crude fiber content of offal meal is determined by boiling the fat-free product (obtained after the extraction of fat with a solvent) in a dilute solution of alkali and acid (0.5$\underline{N}$ NaOH and 0 5$\underline{N}$ HCl) 30 to 60 minutes in each. The residue left after boiling is filtered, dried and weighed. The weight of this residue is expressed as the percentage of crude fiber in the product. The crude fibre fraction estimated contains cellulose, lignin and hemicelluloses. A portion of soluble carbohydrate residues would have dissolved off during the digestion process and if one is keen on a more accurate determination one should estimate nitrogen free extractives which will contain sugars and several undefinable soluble salts. For analytical methods for more accurate estimations, the reader may refer to the references.

PEPSIN INDIGESTIBLE RESIDUE

Pepsin indigestible residue may be determined by digesting a known weight of meat and bone meal with the enzyme pepsin for 48 hours at 37°C. At the end of the digestion period, the residue in the solution is separated by filtration or centrifugation, dried free of moisture and weighed. The percentage of pepsin indigestible residue is the weight of the moisture-free residue per 100 g of meat and bone meal.

Nature of animal fats

Animal fats are those derived from the body fats of domestic animals and other land animals. These fats are characterized by a high content of C_{16} and C_{18} fatty acids (palmitic and stearic acids) and a comparatively low degree of unsaturation. The unsaturated fatty acids are generally oleic and linoleic acids. The configuration of their glycerides bestow them the property of extended plastic range. As a large part of animal fats derived are unfit for consumption as food, their market value is essentially as nonedible fats used mainly as the basic ingredients in soap making.

EVALUATION OF FATS

The commercial value of fats from a rendering unit, processing carcasses, cannot be underestimated. The rendering operation as is commonly understood is essentially designed to obtain fats of the highest quality and the rocovery of offal meal is considered secondary. A carcass utilization centre is also a unit designed to recover fat, the important difference being that the fat produced is *not edible*. International regulations and food acts prevailing in many countries forbid the use of fat obtained from dead animals for edible purposes as mentioned earlier in chapter (6). The fats produced from a carcass rendering unit are diverted for industrial uses (excluding food industry) such as for the production of soaps, fat emulsions, plasticizers, manufacture of fatty acids, commercial grade glycerol or several other fatty acid derivatives. The methods for refining the fats have been described earlier in chapter 7. The standards of quality for fat, for industrial uses are by no means less stringent than those stipulated for edible fats.

A rendering unit processing fats will usually sell the fat to the user by assessment of its colour and freedom from extraneous materials. The cost can be worked out based on the economics of working the centre and striking a via media with the prevailing market prices for similar fats used by the industry.

Some of the typical tests used in the evaluation of fats for quality are outlined (details will be found in references cited) with the objective that the renderer will be placed in a better position to understand consumer needs and if possible improve his process to meet the ever increasing demand for better quality fats. To cite an example, a high content of free fatty acids in fats could be caused by prolonged storage of offals prior to redering. Attempts can be made to shorten storage time or incorporate anti-oxidants in the offals prior to rendering to reduce free fatty acid content in the rendered fat.

The following are some of the tests performed for the evaluation of fats:

1. Titre and iodine value,
2. Colour,
3. Free fatty acids and
4. Moisture and unsaponifiable matter.

Fig. 21 summarises the tests for fats.

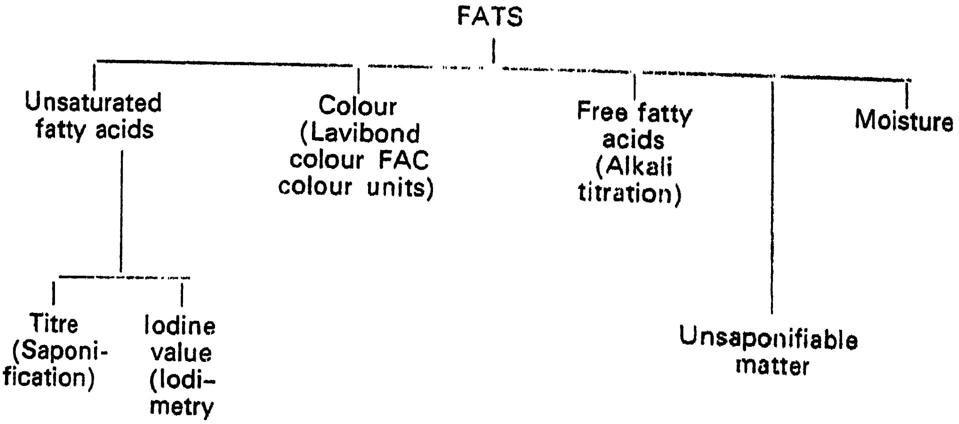

Fig 21 : Tests for quality evaluation of fats.

Titre and iodine value

Titre is a measure of the hardness or softness of fat. Soft fats contain a larger percentage of unsaturated fatty acids. Both hard and soft fats are suitably blended for making soaps. The titre is a characteristic of the species of animal form which the fat is derived and variations in titre also occur between animal to animal of the same species to a lesser extent. There is nothing that a renderer can do to alter the titre as it is determined by the source of raw material.

Titre is determined by checking the melting point of unsaturated fatty acids. The fat to be tested is converted into soap by reacting with caustic potash. The potash soap is then mixed with sulphuric acid by which reaction free fatty acids (FFA) are set free. The FFA are then collected to set hard and then remelted. The melting point in degrees celcius is the titre of that sample of fat. Good quality body fats will have a titre in the range of 42° to 45°C.

Iodine value is a measure of unsaturation of fats and that provides another method of determining the hardness or softness of fat. The iodine value is expressed by the centigrams of iodine absorbed per gram of sample. In estimating iodine value, excess unreacted iodine in the sample is determined by titration. Beef fats of good quality will have iodine values in the range of 43-45.

Colour

The colour of fat is an indication of the extent of abuse the fat has received during rendering. In the rendering plant, the colour of raw fat (unbleached) can be quantitatively measured by the use of a colour comparator or a photoelectric colourimeter. Technically the colour of fat is expressed as Lavibond colour or FAC colour.

In a carcass rendering unit, an approximate colour standard can be drawn up by comparing produced fat with good quality unbleached market fat. The colour of fat can be improved by avoiding delays in the processing of offals and by proper cleaning of raw stock with water.

Free fatty acids

Greater amount of free fatty acids (FFA) in the fats, cause the fat to become rancid sooner. Rancidity is caused by the reaction of FFA with oxygen in air. Thus, high FFA value reduces the shelf life of fats and when used in soap manufacture reduces the glycerol yield significantly.

The FFA content in a sample of fat is determined by direct titration with an alkali in the presence of an indicator.

High values of FFA in the rendered fats indicate poor processing techniques. The raw offal meat contains several enzymes which breakdown the fats liberating

FFA. This reaction is favoured in the presence of moisture. Putrefied offals also have higher FFA caused by microbial enzyme action. Cleaner processing unit, quicker processing of offal and avoidance of resorption of moisture into fats by proper handling and storage and addition of anti-oxidants are methods that can keep FFA at lower levels.

Moisture and unsaponifiable matter

Moisture and volatile matter in fat is estimated by heating the fat to above 100°C for a period and reweighing the sample after it is cooled. Moisture should be low or nil in a good sample of fat. The presence of unsaponifiable matter, i.e. materials that do not form soaps in a sample, could be caused by impurities, contamination with lubricating oils, or high cholesterol content. (Cholesterol is present in considerable amount in brain and spinal chord.) Impurities and foreign matter should be kept at a minimum by careful inspection of washing. Rendered fat can be melted and filtered to remove coarse foreign matter. Excessive agitation of fat during processing should be avoided as fat can form emulsions with water and other materials causing high moisture content and unsaponifiables leading to low filtration rates.

CHAPTER—IX

Rendering of Exotic Animal Offals and Fish Offals

The rendering operations described thus far centred around techniques applicable largely to carcass of ruminants namely cattle, sheep, and goats. The removal of stomach contents which constitute nearly 6-15 per cent of the bulk of the carcass is an essential step while rendering ruminant carcasses. The stomach contents, if not removed, will add a considerable amount of crude fibre much above the normal permissible value of 3 per cent to the final product. The rendering of monogastric (simple stomached) land animals does not necessitate the removal of stomach contents, as their diets would be essentially non-fibrous in nature and therefore do not contribute to crude fibre in the finally prepared offal meal.

Horses, donkeys, pigs, dogs and poultry are included as examples of exotic animals. Fish will be dealt with separately.

Horses and Donkeys

Horses and donkeys can be flayed by conventional flaying techniques. The larger number of subcutaneous muscles make flaying somewhat cumbersome and the adhering flesh to the skin is usually much more than for cattle. Horses and donkeys are monogastric animals, but the bulk of the fibre is stored in their caecum, which is the lowest part of the alimentary canal before it joins the rectum. Similar methods to remove the contents of the caecum as that applied to rumen can be followed. Strict hygienic methods adopted to cattle carcass are equally applicable. The hoofs are removed and the tail hairs may be removed by close clipping. Horse and donkey tail hairs are valuable and fetch a good market price. The yields of offal meal are similar to cattle carcasses, but the yield of fat is usually lower and the fat is highly coloured.

Pigs

Pig carcasses are not usually flayed. The whole animal, if small, or cut into pieces if large, can be taken for rendering. The hoofs are usually small and need not be detached. The yield of offal meal is 15-17 per cent and of fat 15 per cent. The hair and bristles on the animal can be removed prior to rendering either by burning (singeing) or by scalding with boiling water and scraping. Bristles fetch a good market price if they are recovered by scalding. They are washed clean and dried in shade. Body hair is of little value.

Dogs

The rendering of dogs has been shrouded with controversy from ethical values and dogma, besides doubts cast on the possible risk of contracting rabies by handlers. The carcasses of dogs may be available, particularly when municipalities take up intensive programmes for rabies control. Dogs captured thus are held in kennels for some days to protect the owners' claims and later euthanised by fumigation or electrocution. Flaying these animals is not safe as much as they have been rounded up to avert the possible menace of rabies. Flaying involves handling and it is difficult to set norms for safe flaying. If a rendering unit is at hand it is certainly much more profitable to render the animals, rather than disposal by burial or incineration. The whole animals (not flayed) are rendered and the hairs which are not digested by conventional rendering methods (rendering at pressure above 5.5 kg/cm^2 or 80 psi digests hair also) are present in sufficient quantity in fat and offal meal. It is possible to separate the hairs contaminating the fat by filtration of molten fat. The offal meal obtained is best disposed as nitrogenous fertilizer supplement. Feeding this offal meal to animals is not advisable as the hairs will gradually accumulate in the stomach or intestine and form hair balls, a pathological condition called pili bezoars. Their presence causes chronic digestive disturbances and at times proves fatal due to obstruction and colic.*

It has been suggested by several authorities involved in rabies eradication programmes, that dogs kept for 21 days under observation are safe and can be flayed. Firstly, maintenance of dogs for 21 days in a kennel is uneconomical and this period of impounding provides no assurance of freedom from rabies. Further, if one dog in the batch is identified rabid, then it goes without saying, that the rest are now in the incubation period and are likely to succumb to rabies. No method followed is safe and flaying is entirely inadvisable. The rendered fat and offal meal are however safe and can be used without any hesitation in soap making and as a fertilizer supplement respectively.

It might be possible to singe (burn) the body hair of dog and then render the carcass as a whole. This method does not seem to be in practice and is worth a trial. The dog carcass can be conveniently singed without much handling using a jet burner (Etna burner), washed by scrubbing and rendered. By this method, it should be possible to obtain an offal meal of quality suitable for use in animal feed supplement.

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*It is also possible to separate the hairs from ground, whole animal offal meal by winnowing or similar mechanical gravity separation devices. This meal, free of hair, can then be used as animal feed supplement.

The problem of teeth

As stated earlier, undigested teeth may be found in offal meal of any kind and these are best hand picked during coarse grinding or by seiving. Heavy duty grinders will crush them to a powder, but damage to the crusher in the process cannot be ruled out.

QUALITY EVALUATION OF MEAL AND TALLOW

Methods discussed in chapter 8 are equally applicable to these rendered products. Table 9 gives the differences in the composition of saturated and unsaturated fatty acids in some animals.

TABLE 9

Approximate composition of saturated and unsaturated fatty acids in fats from different animals

Nature of fat	*Saturated fatty acids (%)*	*Unsaturated fatty acids (%)*
Beef tallow	60	40
Mutton tallow	53	47
Pig fats	40	60
Horse fats	36	64
Domestic fowl fats	26	74

Poultry offals and other keratinous offals

Soft offal parts of poultry such as digestive organs and condemned dressed meat can be included along with the regular offal materials for rendering. Skin with feathers, head and hind legs of poultry cannot be included in regular rendering process. These are highly keratinous, being similar in composition to horns and hoofs of ruminants and when mixed with other offals add predominantly to pepsin indigestible residue and are of very low nutritive value. All types of keratinous materials are rendered separately and pressures as high as 5.5–8.0 kg/cm^2 (80–120 psi) are required to prepare horn and hoof meal or feather meal. These meals best serve as fertilizer supplements and are valued for their soil binding property and as slow nitrogen releasers for long term crops, or for use in tea, vines and in potato gardens. Hoof and horn meal as well as feather meal are superior to bone meal as their nitrogen content can be as high as 14 per cent (85 per cent crude protein). Feather meal has been included in poultry feed supplements, to replace up to 5 per cent of total protein in the ration. Supplementation of larger amounts has not been found beneficial. Comparing feather meal with meat meal for chicken feed, it is observed that meat meal is well digested but has a poor amino acid balance, whereas feather meal protein not only has a poor amino acid balance but is also poorly digested.

Clean pulled poultry feathers have a market for the manufacture of dusters and many fancy articles. Waste hoof and horn meal or finely ground unrendered as well as rendered material serve as a starting material for the manufacture of a foam compound for fire extinguishment.

Fish offals

Fish offals are of different categories. Non-edible protions of fish obtained from fish canning factories is one type of offal. Fig. 22 provides an idea of wastes obtained from a Salmon cannery. These wastes are fins, digestive tract, male or female reproductive organs, heart, liver, and head. The second type of fish offals are the non-edible fishes sorted out from the fishing nets in large scale fishing. Edible fishes that have been condemned as unfit for food due to putrefactive changes or other reasons form the third category. Fish offals can also be divided depending on the nature of stock as oil yielding varieties and varieties from which oil recovery is not economical. The main factor that determines the type of rendering to be applied is the oil content of the offal. Fish offals with low oil can be dry rendered. Fish offals with high oil are wet rendered in order to recover oil of good quality.

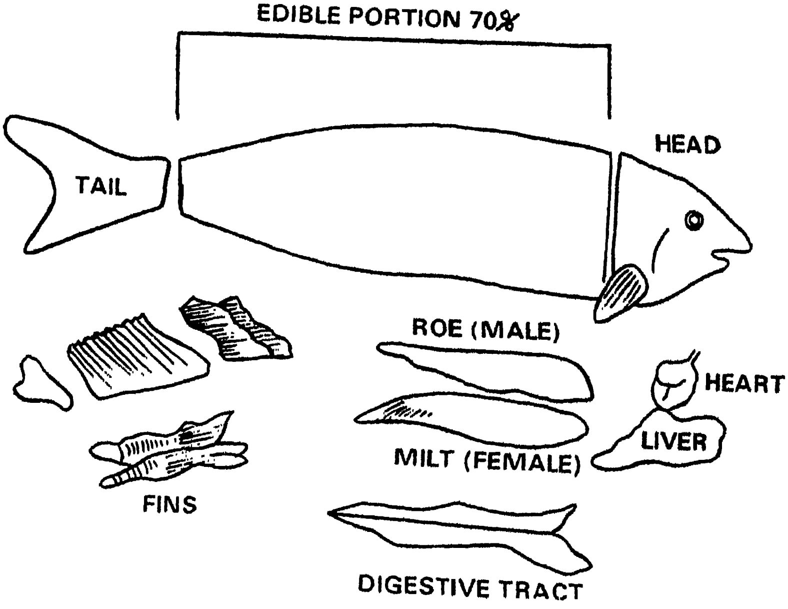

Fig. 22 : Fish wastes that are obtained from a fish canning factory.

DRY RENDERING

Dry rendering is applied generally to fish offals with low oil content. The small yield of oil expelled from the dry rendered stock is highly oxidized and its presence in dry rendered fish meal can lead to rapid spoilage of fish meal on storage. The principles of dry rendering are the same as that described under dry rendering in chapter 7, excepting that oil recovery is high or low depending on the type of fish offal rendered. Specially designed hoggers to reduce fish offal followed by dry rendering plants designed for the purpose are used, but the carcass unit dry renderers can equally serve well. The fish meal is dried to contain 6-8 per cent moisture; the oil from press liquor is not of any commercial value, except as burning oil. Dry rendered fish meal contains a large proportion of water soluble compounds of high nutritional value and fetches a high value as feed supplement. The yield of fish meal from dry rendering is around 20-25 per cent depending on the quality of raw stock.

WET RENDERING

Large and continuously operated wet rendering plants are installed where fish offal stocks with high oil content are available in copious amounts. This is the usual practice followed in the United States of America and many other developed countries. Commercial batch type wet rendering units can also be used for rendering fish offals after evaluating the economics of the process. The principles of wet rendering are similar to those described under wet rendering in chapter 7. The wet rendered offals can be separated into a large quantity of liquid stick and a small fraction of solids. The solids are further pressed and dried into fish meal. The press liquor is high in oil. The liquid is separated from coarse suspended solids by filtration through vibrating screens. The liquid is then fractioned either by gravity separation or by centrifugation (in cream-separating centrifuge type models) into the oil and the liquid stick containing fish solubles. The further processing of oil involves a complex technology and is not discussed here and the details can be obtained from references cited.

Earlier practice was to discharge the liquid stick into the sewers as waste. The liquid stick is highly putrecible and provides an ideal microbial media. Its discharge into sewers could be objectionable due to its high BOD value. The fish solubles contain constituents of very high nutritive value and an analysis of condensed fish solubles is given in Table 10.

The fish solubles are acidified from its initial pH of 6–7 to pH 4.5–4.8 by the addition of sulphuric acid. The acidified liquid when heated, results in the coagulation of proteins which can then be separated by filtration. The solids are further pressed and dried in driers at as low temperatures as is practicable.

TABLE 10

Composition of condensed fish solubles

Component	*Per cent*
PROTEIN	
(Essential amino acids in proteins)	
Amino acid	*Protein*
Phenyl alanine	2—2.5
Leucine	4—5
Isoleucine	2.5—3
Valine	2.5—3.2
Lysine	4—5
Threonine	2—2.5
Methionine	1—1.8
Tryptophan	0.2—0.4
(Additional amino acids essential for poultry)	
Histidine	3—6
Arginine	4—4.5
Glycine	10—11
FAT	3—6
FIBRE	0—0.5
ASH (Calcium, Phosphorus (1 : 1) Iron, Magnesium, Sodium and Potassium oxides)	8—10
B GROUP OF VITAMINS	3000—4500 mg/kg

YIELDS

In general, 1 ton of fish offal will yield 150-200 kg of dry fish meal and 800 kg of press liquor. The press liquor will yield 100-140 kg of oil and 25-30 kg of condensed fish solubles, the yields again being dependent on the type of raw fish offals processed. An approximate composition of dry rendered fish meal is given in Table 11 and that of condensed fish solubles in Table 10.

TABLE 11

Approximate composition of dry rendered fish meal

Component	*Per cent*
Moisture	6—10
Protein	60—70
Ash	16—20
Oil	4— 8
Pepsin insoluble residue	Less than 1
Crude fibre	Less than 1

NUTRITIVE VALUE OF FISH MEAL

The protein content and nutritive value of fish meal differ greatly with the manufacturing technique followed. The difference in nutritive value is mainly due to the variability of 'available lysine' in the fish meal. Prolonged or severe heat treatment seems to chemically alter the availability of lysine. Lysine in fish offal has been experimentally found to combine with the amide group of asparagine and glutamine and also perhaps with sulphur containing amino acids to form new peptides when over heated. These newly formed peptides are either not hydrolysable or are stearically hindered from absorption when fed to animals.

CHAPTER—X

Delayed Rendering and Storage

Delay or postponement of rendering of the offal stock is undesirable. Delays in rendering could at times be unavoidable due to several reasons, for example, the rendering unit may be located far away or poorly connected with the area where the animals have died. Calamities may take a heavy toll and more number of animals than a rendering unit can handle may become available. Under such circumstances storage of carcass offals under refrigeration will be very ideal. But refrigeration is expensive and therefore not economical. What seems most needed under such circumstances is to keep offals without putrefaction until rendered. There seems to be no alternative for best results, but, either to store by refrigeration or avoid storage. What really supports putrefactive changes is the water content of the offal. Drying of offal to a low moisture content so that it can be stored for a short time can be attempted. Methods adapted for drying or installation of drying equipments at closely located centres, could work out cheaper than having many rendering units. Drying of offals is certainly not a practice to be recommended as a regular technique; but could be considered as an alternativo to totally discarding offal meat.

Drying

The carcass can be flayed and opened in the manner described earlier. The offal material should now be cut into smaller pieces or preferably compacted into as small chunks as possible. The bones and fat have to be removed and cooked in open kettles to recover the fat. The small meat chunks are now dried in driers. Several types of driers are commercially available or could be designed to suit one's requirement. Heating is accomplished by electrical energy, by coal or oil firing. Forced air circulation driers with a forward flow of air are most suitable. The drying process is however cumbersome and protracted. For example, 1 cm^3 of cooked meat takes about 22 hours to reach 8 per cent moisture content, which means that raw offals will take even longer drying time. When meat is minced, the drying time is somewhat shortened to between 4·8 hours. The presence of fat also delays drying.

Oven dried offals can be sacked and transported to the rendering units at the earliest possible time. Otherwise the dried material is prone to attack by insect pests and rats. Dried meat also picks up moisture rapidly and supports fungal growth.

Offal stocks infested with fungal growth show up as cotton wool on the surface of meat and the meat is coloured green to black by presence of fungal spores. Such stocks should be carefully handled to minimize raising dust and are preferably burnt. Fungal spore dust could be dangerous when inhaled and at times prove toxic when rendered as offal meal for stock feed. Alternatively, the dried contaminated meat could be moistened and spread in fields to serve directly as fertilizer. Sprinkling of lime over such area may detest vermin infestation of soils.

SOLAR DRYING

In hot dry and sunny climatic zones solar drying may prove as the best alternative and can be practised under rural conditions with very little investment. The meat chunks can be strung or tied on coconut fiber or nylon ropes (cotton ropes spoil rapidly) and hung on wooden poles at sufficient height under sun. Sprinkling a lime slurry prior to drying is beneficial. Drying under sun may be complete in three to four days time. The dried chunks can then be transported to a rendering unit.

A few advantages that can be derived out of drying are (i) the total weight of material transported is considerably reduced, (ii) transportation in sacks is far more convenient than transporting unwieldy whole carcasses (iii) the rendering capacity can be enhanced, meaning, the rendering vessel that can take 1 ton of raw offal can easily accommodate 3 to 4 tons of raw offal that has been dried to weigh ultimately a ton.

The disadvantages as stated earlier are many. Added to those mentioned, the fat and offal meal recovered are of poorer quality and have a lower biological value. Dried offal may at times turn stone hard and in such cases the time of rendering should be sufficiently prolonged. The yield of offal meal may be reduced by as much as 10 per cent over that obtainable from raw offal meal. This happens because a large amount of offal undergoes hydrolytic changes during drying, contributing to greater amount of solubles. Losses therefore are greater when dried offal meat is wet rendered than when dry rendered.

Lime when used during drying should be washed by soaking in warm water and then should be washed in cold water (lime is more soluble in cold water than in warm water).

Large scale deaths

When large scale deaths of animals occur due to out break of diseases no attempt should be made to recover the skin or carcasses unless under veterinary public health advice. In situations like floods, drought or other calamities, a large number of carcasses may become available. Under such circumstances the skin of such animals are invariably recovered and the carcasses go unutilized. Certain methods are recommended below which may be worthy of consideration in such conditions.

DRYING

Drying as suggested earlier is one such method that can be considered. Drying may be impractical under situations like floods or heavy rains.

LIMING

Carcasses may be opened by techniques described in earlier chapters and carcasses sprinkled with lime or smeared with lime and stored in sheds until it becomes possible to dry them. Carcasses can also be dumped into pits and limed and later reclaimed for drying.

BURIAL

The carcasses can be buried as such or dismantled and given a community burial. Buried areas may be opened after a period of one or two months and bones can be recovered. Burial with lime is any time preferable as this may minimize foul odour and keep the bones in a good state of preservation.

Processing of recoverd bones

Bones recovered from any of the above methods are valuable by-products. It is not desirable due to ethical and public health reasons as stated in chapter 6 to send them to bone crushing industry. The bones can be rendered in dry or wet rendering plants to obtain steamed bone meal. The yield of bone meal is 75-80 per cent the weight of bones by wet rendering and 90-95 per cent by dry rendering. The bones can also be burnt in open or in incinerators to make bone ash. The yield of bone ash is 50-60 per cent of the weight of bones. Bone ash is used as a phospatic supplement in feeds, preparation of cattle licks and as a fertilizer for acid soils where it acts as a buffer. Good quality bone ash, i.e bone ash that is uniformly white and contains very little foreign material, is used as a component in the manufacture of ceramics, famously termed bone china.

Storage

Storage of raw offal material has been discussed in some detail in chapter 6. Some additional information on storage of fat and offal meal is provided in this chapter.

HANDLING AND STORAGE OF FAT

The suggestions given here are near ideal. The data given are abstracted from information published by the National Renderers Association (NRA), USA with some modifications to suit the needs of a utilization centre. It will be desirable to follow these procedures to the extent possible.

Technical grade and animal feed grade fats are usally transported in 200 litre drums. These drums have two openings, one large opening about 50 mm in diameter and the other small one about 20 mm. The openings are closed with screwed metal plugs. Fat can be removed from these containers only in a liquid state, that is only after melting.

In the rendering plant, fat is filled into the drum every day, the drum also thus serving as a storage bin. The fat in the drum is in a solid state during storage. A few such drums may be sufficient as returnable containers for small rendering units or in units where facilities to dispose fat at frequent intervals are available. In the case of units which recover larger quantities of fat or have the need to store fats for longer periods, the containers described below will be suitable.

Double walled containers of higher capacity (capacity to be determined) with a conical or inclined bottom as shown in Fig 23 are most suitable. The containers have a double wall so that they can be heated by steam to melt the fat. The storage bins of this kind have two taps for draining the fat. One tap is situated above the conical bottom or above the slant (Fig 23) and another at the extreme bottom surface through which it is possible to empty the container completely. The upper opening through which the fat is filled is a 50 mm one with a screw cap or with any other type of air tight plugs. A ventilation tube for air outlet which is an inverted 'J' tube is also provided at the top.

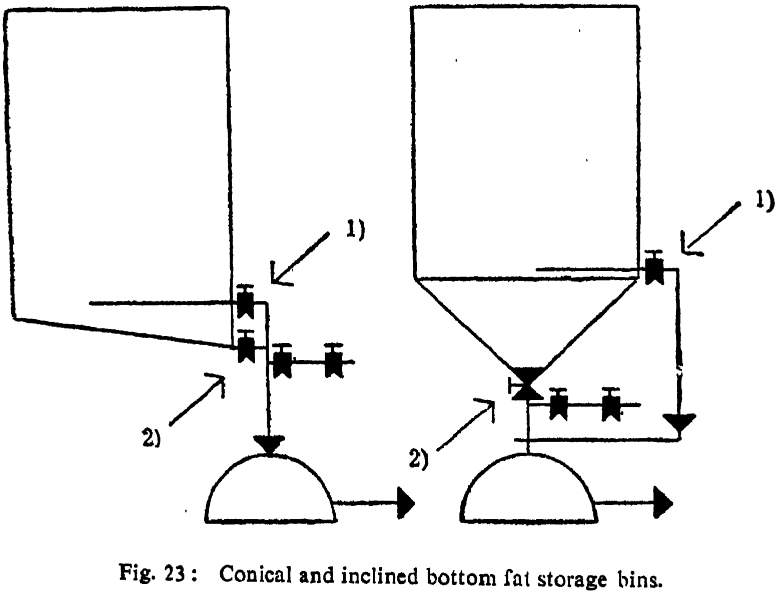

Fig. 23 : Conical and inclined bottom fat storage bins.

Molten fat, still hot form the rendering unit is poured into the container through the top 50 mm opening. When fat is required to be drained for use, the container is heated by steam to melt the fat into a liquid state and the oil is drained through the upper tap (tap 1 in Fig. 23). Some amount of suspended matter, other undissolved material and water (separated from fat during storage) settle to the bottom as sludge, and can be drained out as waste or for use as burning oil at frequent intervals through tap 2 (Fig. 23).

As an alternative to using a double walled container for storage, a steam coil can be run round the storage bin or provided at the bottom of the container. It is to be noted however that heating to melt the fat should be as rapid and uniform as possible which means that local hot zones or pockets that over heat fats nearest to the heating coils are undesirable. The critical factor therefore is to achieve uniform and rapid melting and this should be borne in mind while considering any alternate design for storage tank for fat.

Certain heat requirements to melt fat recommended by NRA are reproduced below for the benefit of designing storage tanks to melt fat.

The largest amount of heat is required for melting; with melted fat, it is only necessary to make up for losses to keep it warm. For heating solid fat 0.6 Kcal/kg for each degree centigrade is needed. The amount of heat required for melting is 35 Kcal/kg and for overheating 0.4 Kcal/kg/°C. If the temperature of the solid fat at the time of delivery and at the beginning of melting is 10°C and the melting temperature 40°C, and if fat is to be heated to 80°C, it is necessary to provide the following heat for each kg of fat:

$Q = t_K C_K + r + t_l C_l$ (Kcal/kg) where t_K - heating the solid fat to melting point; $C_K = 0.6$ - spec. heat of solid fat (Kcal/kg°C); $C_l = 0.4$ (Kcal/kg) spec. heat of liquid fat; $r = 35$ Kcal/kg-latent melting heat; t_l - temperature of overheating; $Q = (40-10) .\ 0.6 + 35 + (80-40) .\ 0.4 = 18 + 35 + 16 = 69$ Kcal/kg

If steam is used for melting, the use of saturated steam is recommended to ensure a better heat transfer on to the pipes by which the fat is heated.

The temperature of steam increases with pressure. Too high pressures are not recommended because of the risk of spot overheating and because they make the handling of the connecting pipes more difficult. The pressure is usually between 2 and 4 atm, which means that the temperature of the steam is between 130° and 150°C.

1 kg of saturated steam under a pressure of 2 atm contains about 650 Kcal. The temperature of the condensate which comes out of the heating pipes is about 90°C. This leaves for the heating of the fat:

$Q_p = 650\ 90 = 560$ Kcal/kg

1 kg of steam can melt and heat :

$$G_M = \frac{Q_P}{Q} \qquad \frac{560}{73} = 7.7 \text{ kg of fat}$$

Taking into account possible losses, it is estimated that one kg of steam will melt 7 to 7.5 kg of fat.

For smaller installations electrical heating using thermostatically controlled L shaped heaters are advisable (Fig. 24.) The heaters are of 2000-3000W and fat is heated to a temperature not exceeding 75°C. Some information on electrical energy required in this case is reproduced from the NRA data.

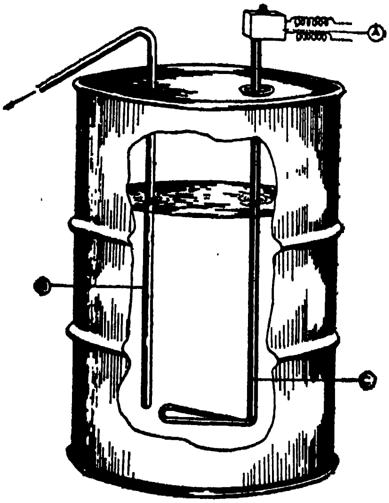

Fig. 24 : Fat storage vessel with an 'L' shaped electrical heater.

In electrical heaters, the whole electrical energy is transformed into heat and transferred to the fat. 1 KW/h of electrical energy is equivalent to 860 Kcal/h which means that electric heaters of 3000 W = 3 KW will produce 3 x 860 = 2,580 Kcal/hour.

The time required for melting 150 kg of fat is theoretically as follows :

$$T = \frac{150 \times 73}{2580} = 4.25 \text{ h or } 4 \text{ h } 15 \text{ min.}$$

Practically, one heater will take about 5 hours to melt a 150 kg (200 litre) drum of fat.

As per the recommendations of NRA, it is desirable to store fat in the fluid state by keeping the tank continuously warm at 50°C. However, if the storage is longer than a fortnight, the fat may be left to solidify. In the former case, thermal insulation of tanks can provide an advantage to keep the fat in molten state. The moisture in fat gradually separates and settles at the bottom of the vessel, which should be frequently drained out along with sludge as mentioned earlier.

Cleaning of storage tank

When tanks in which fats are stored get empty, cleaning of the storage tank is very important. The tank must be inspected and rusty spots should be attended to by covering with a protective coating resistant to fat (acrylic emulsion paints are commercially available for such uses). Cleaning of tank cannot be achieved by ordinary mechanical scraping. Flushing with steam or boiling water cleans the tank reasonably well. At times, cleaning with caustic soda and boiling with a solution of the same in the tank should be beneficial. This treatment also converts the adhering film of fats into soaps and aids cleaning. The sludge and other solid adhering matter is mechanically removed prior to cleaning. It is important to dry the tank thoroughly to cleaning. It is important to dry the tank thoroughly before refilling with fat as moisture will adversely affect fat quality and promote rusting of tank during storage of fat.

It is also desirable to check for leakage during cleaning operation. Any contact with mineral oil or other extraneous materials during cleaning must be avoided.

Further details on storage and handling of fats can be found from references cited.

HANDLING AND STORAGE OF RENDERED OFFAL MEAL

Proper handling and storage of offal meal is of paramount importance, as much as it is a good manufacturing practice.

Rendered offal meal in its final form is a granular material containing between 8–10 per cent moisture. As has been stressed earlier, the content of moisture is what determines the shelf life of the material. Offal meals that have been processed with minimum handling and processed under scrupulously hygienic conditions will store well for over six months if sealed and stored in air tight containers such as drums or polythene sacs. Poor storability relates to the degree of abuse the offals had during processing. Offal meal can very easily get contaminated with insect pets, fungal spores and gathers an undesirable moisture content and spoils very rapidly. Offal meal with high fat content is also amenable to rapid spoilage due to oxidative rancidity of fats during storage. The best offal meals are therefore those that have been very little abused during production and have the right moisture and fat content.

Water activity

Preservation and storage of manufactured products aims at extending the useful shelf life and distribution at the required time. Several factors that influence preservation (chemicals, temperature of storage and moisture content) have been discussed earlier. It is obvious that the presence of water or moisture greatly influences all forms of life and in turn, in the present context, affects storage. It is not that water by itself could do harm, but it is its presence as a solvent that aids in transporting in and out the nutrients needed to support life. In the context of preservation, the available water/moisture supports and allows undesirable multiplication of bacteria and moulds (microbes) which ultimately cause spoilage of preserved materials by several ways. The microbes that proliferate during storage can be harmful by themselves causing food poisoning (salmonella), or alter the nutritive value and palatability, or produce toxins. For all these to happen, water or moisture must be actively available.

All proteinous materials (offal meals in this case) contain water in the form of moisture and also contain water chemically bound to the protein molecules. The chemically bound water does not contribute directly to the availability of water or moisture for microbial growth at the first instance. Microbial metabolism can however ultimately release this water as well to add up ultimately to the undesirable moisture content. The availability of water for microbial growth and consequent spoilage can be prevented by minimizing, what is termed the 'water activity' (a_W) value of the system. The water activity value can be altered, for example, by freezing, or by changing the osmatic pressure of the system, such as is done in pickling with salts or sugar. In these cases, the state of water is altered thus making it unavailable for microbial growth. We now see that the determination of total moisture content alone, although gives a clue to the amount of water present, does not tell us whether this water or moisture is really harmful to cause storage losses or not. For example, pickled material contains a very high percentage of moisture, but this does not directly contribute to spoilage during storage. Thus, water activity rather than the actual water content determines the lower limit of available water for microbial growth. The water activity value thus conveniently determines the ability of an offal meal to preserve and provides a sensible unit of assessment of possible spoilage during prolonged storage. An offal meal, for example, may be found to have an initial moisture content of 8 per cent and thus expected to store well, but may absorb moisture during storage and thus spoil, consequently the initial moisture content value determined becomes meaningless.

Water activity can be understood for the present purpose as: Water activity (a_W) is equal to the equilibrium relative humidity (ERH) divided by 100.

$$a_W = ERH/100$$

Several methods are available for determining the water activity of a product. Accurate methods of measurement and a discussion on the same in detail can be found in the references cited. A simple though not a percise method is suggested here, which can be adapted for the practical evaluation of water activity of offal meals.

MEASUREMENT OF WATER ACTIVITY OF A SAMPLE OF OFFAL MEAL

The moisture content of a sample of offal meal is determined by the method discussed in chapter 8 under the heading 'Estimation of Moisture, Fat and Nitrogen'. A weighed sample (say 10 g) of the same offal meal of known moisture content, well spread out on a plate is enclosed in a dessicator chamber in which a saturated solution of sodium nitrite ($NaNO_2$, 150 g/100 ml of water) is kept instead of calcium chloride, the usual dessicant. The dessicator thus prepared has a standard relative humidity (RH) of 65 per cent. The dessicator is preferably kept in a constant temperature chamber. As the change in RH is small with small fluctuations in environmental temperature, it is sufficient if the dessicator is further enclosed in a cardboard or deal wood box and kept in a room, where temperature fluctuations are minimal. Sufficient time, say 72 hours, is allowed to attain an equilibrium of offal meal with the environment inside the dessicator. The offal meal is then taken out and the moisture content determined without delay. The initial moisture content (M_1) of the original sample divided by the final moisture content (M_2) of the sample kept in the dessicator, both expressed as percentages gives the water activity (a_W) of the sample.

$$a_W = M_1/M_2$$

A water activity value below 0.8 is considered ideal for offal meal and it is stated that water activity is independent of storage temperature within the range of microbial growth. Typical a_W values which support the growth of certain spoilage microbes during storage are given in Table 12.

TABLE 12

Water activity values for spoilage microbes

Microbe	*Minimum a_W value*
Halophilic bacteria	0.75
Xerophilic bacteria	0.65
Osmophilic bacteria	0.60
Normal bacteria	0.91
Normal yeasts	0.88
Normal moulds	0.80

Infestations

The offal meal is also prone to infestation by insects, outstanding among which is infestation by the dermestes beetle. Properly sealed containers which have been handled with least exposure to air and good hygiene will remain safe from infestation. Punctures and cuts on the bags, besides loss of material also re-expose the containers to insect infestation and uptake of moisture. The chances of re-contamination with salmonella organisms cannot also be ruled out.

It is most desirable therefore that the offal meal prepared under hygienic conditions be packed and sold for use at the earliest period possible. If storage is a must, the bags or drums containing offal meal are sealed well and kept in properly constructed store houses protected from dampness and vermin infestation. A well ventilated store house is preferable. The stored material should be frequently inspected to ascertain damage, if any.

FUMIGATION

Fumigation of stored material will be suitable if prolonged storage is envisaged. Fumigation is carried out by agencies who can advise on the right type of treatment required. It is important to note here that fumigation does not dispense away any of the care needed in storage and every effort is needed to prevent re-infestation of the stored offal meal that has been fumigated.

When consignments are returned on complaint of contamination with salmonella organisms, it may be possible to free the offal meal from salmonella by heating it to 110°C for a period of 90 minutes. The heat-treated product is then packed without re-exposure to unhygienic conditions.

Storage losses

Besides losses caused by insect damage and rodents, prolonged storage by itself is detrimental to the quality of offal meals. The digestability of the offal meal is reduced with storage, almost being halved on storage for a period of six months. This is effected by the denaturation of proteins caused by the residual moisture, heat and by the oxidative changes in residual fats. Stored offal meal will also change in colour from the initial light brown shade to dark brown and finally black, thus making it unattractive for sale. The colour change is caused by the oxidative changes taking place in the pigments of animal origin such as haemoglobin and metheoglobin. The offal meal also turns gradually acidic on storage due to bacterial action and this may in turn catalyse rapid deterioration during storage. The presence of carbohydrates especially fillers such as bran or similar materials in larger quantities adversely affects the quality of offal meal by promoting fermentation and reducing the biologically available lysine value. It is for this reason that it is preferable to keep offal meals, bran and other feed constituents separately and prepare feed mixes whenever needed. Prepared feed mixes have a much lower shelf life than individual components of the feed mix under similar conditions of storage.

CHAPTER—XI

Energy Calculations for Offal Processing

Every unit operation in the processing and preservation of offal material, namely rendering and drying, requires heat energy. When heat energy is supplied to complete a process, heat transfer is said to have occurred. The transferred heat is what accomplishes the process of heating, cooking, a chemical change, separation and melting of fat and drying of offal meat. Heat transfer is therefore a prime consideration in the design and operation of rendering processes. Maximal efficiency, meaning minimum energy consumption can be achieved by proper design and construction of the operating machinery. This is of utmost importance and reflects greatly on the economics of the process by cutting out recurring expenditure, although a better designed equipment may at the first instance involve a higher capital investment.

Certain basic data and preliminary equations that will be of use to a designer of offal processing plants are provided, realizing however the limitations and the magnitudes, the subject can be further extended to. It should also be borne in mind that the actual design based on heat inputs and total energy requirements are best left to the specialists in the field. What is aimed here is to equip the offal processor with some information in order that he may be able to communicate the information the specialist needs and understand why he needs them.

Heat Transfer

Heat transfer into any medium is governed by physical laws. *Thermal conductivity* and *specific heat* of materials are the unit constants that largely determine heating efficiency besides other factors. Differences in thermal conductivity in a material are due to the differences in the abundance of free electrons. Metals are good thermal conductors owing to the abundance of free electrons, whereas meats and most offal products, where water is the main constituent, have a low concentration of free electrons and hence are poor thermal conductors.

It is interesting, as an example to note here, that the thermal conductivity of ice is nearly four times greater than that of water. During freezing of meats, heat is conducted into the material through the ice layers subsequently formed, and therefore resistance to freezing is less and heat flow is efficient. While thawing (melting), on the contrary, heat should be lost through layers of water formed on the outside and thawing therefore is comparatively difficult. Consequently, the thawing of meats is inherently a slower process than freezing. This phenomenon will be important when one obtains frozen offal meats for rendering and energy requirements for thawing prior to rendering become important.

MECHANISM OF HEAT TRANSFER

The transfer of heat to a mass of material is dependent on the specific heat of a substance. Specific heat is a dimensionless unit of heat capacity of the substance. Heat capacity will be the amount of heat energy required for a given mass at a temperature to raise by 1°C. In the cgs system (metric system), the heat capacity is the number of calories required to raise 1 g of the substance by 1°C. One calorie in turn is the heat capacity required to raise 1 g of water by 1°C (from 14.5°C to 15.5°C) The specific heat of a substance can be calculated by the following equation

$$\text{Specific heat (sp)} = \frac{C_p \text{ of the substance}}{C_p \text{ of water}} \qquad (1)$$

Where C_p indicates the heat capacity in calories/g°C at constant pressure. Heat capacities of meat and some other materials are given in Table 13.

TABLE 13

Mean heat capacity values of meats and other materials (between 0°C and 100°C)

Material	*Water content*	*Heat capacity*	
		btu/Lb/°F	*Calories/kg/°C*
Pig meat	50	0.48	0.120
Beef — fatty	51	0.69	0.175
Beef — lean	72	0.82	0.206
Beef, mince meat	—	0.81	0.204
Bones	—	0.4 — 0.6	0.1 — 0.15
Mutton	90	0.93	0.234
Fats — Solid	—	2.4	0.6
Fats — liquid	—	1.6	0.4

From the data supplied in Table 13, it is possible to calculate the quantity of sensible heat transferred to the system. Sensible heat is the heat that can be 'sensed' or the heat input that causes a rise in temperature. The sensible heat transferred is calculated by the equation

$$q = mC_p\ t \qquad (2)$$

Where q is the sensible heat transferred (Calories) ; m is the mass of the material (g), C_P is the heat capacity (Calories/°C), and t is the temperature change of the product (°C).

While applying equation (2) it must be remembered that the heat requirement obtained is a theoretical value. This means that the application of heat needs a heating source, a container to heat the material, as well as a specific area of exposure of the material for heat transfer. Thus, equation (3) should be considered

$$q = uA\,t \qquad (3)$$

Where q is the quantity of heat transferred by the equipment (Calories) ; u is the overall heat transfer coefficient. i. e. q of equation (2), A is the area over which heat is transferred(cm^2) and t is the temperature difference between the heat input source and temperature to which the material is heated.

Based on the calculations stated above, as an example, nearly 95–190 kg calories or 0.43–0.9 mega joules of energy may be absorbed actually by the meat and the energy expended would have been in fact much more being in the range of 360-410 kg calories or 1.5 to 1.7 mega joules, the difference being caused by loss of heat into the environment.

The rate of transfer of heat to a material under consideration is achieved by thermal conductivity. Heat by conduction is caused when the material to be heated is completely in direct contact with the heat donating source. Heat by convection is caused by mixing of warmer and cooler portions of the material and is applicable to fluids. Heat by radiation is caused, for example, by exposing the material to a hot flame. Here we shall be primarily concerned with heat by conduction for purposes of simplicity and understanding, although transfer of heat by convection and radiation are also practicable. The rate of heat transfer can therefore be expressed by equation

$$\text{Rate of heat transfer} = \frac{\text{driving force}}{\text{resistance}} \qquad (4)$$

Driving force can be taken as the difference in the temperature established between the material and heat source. As an example, to boil water, a driving force is necessary. Steam at 100°C cannot bring water to boil as there will be no net heat transfer and steam above 100°C will provide the driving force. The greater the temperature difference between the heat energy source and material that is heated, the shorter will be the time needed to heat water or other materials of a given mass.

The resistance stated in equation (4) is the thermal conductivity of the material. Data on thermal conductivity of different materials are available in chemical engineering data books. Some selected thermal conductivity data of materials of interest are given in Table 14.

TABLE 14

Approximate thermal conductivity values of some materials

Material	*Thermal conductivity* (btu hr^{-1} ft$^{2-1}$ °F-1)	Cal/hour^{-1} cm$^{2-1}$ °C-1)
Water 93°C	0.314	4.673
Air 20°C	0.0148	0.220
Meats (average at 0°C)	0.290	4.316
Stainless steel	9.4	139
Copper	230.0	3422

Thermal conductivity is a proportionately constant k and it is a physical property of a material through which heat transfer occurs. The units of k can be derived from equation (5).

$$K = \frac{\text{btu ft}}{\text{hr ft}^2\ {}^\circ\text{F}} \quad \text{or} \quad \frac{\text{Cal.cm}}{\text{Sec.cm}^2\ {}^\circ\text{C}}$$

Meat and offal products have a remarkably low thermal conductivity (k) values compared to metals. As stated earlier, this is due to the high water content of meat and offals.

CHAPTER—XII

Alternatives to Rendering

Burial of animal carcasses and final recovery of bones, as an alternative to rendering, has been outlined in chapter 10. Mass incineration could also be one another alternative and the resultant product, namely ash, can serve well as a phosphatic fertilizer supplement. Incineration of whole carcass is by no means inexpensive but the resultant ash may not yield significant profits. Certain methods suggested in this chapter as alternatives to rendering should be considered as recommendations that deserve attention, rather than as better alternatives. The reasons for this are that the methods suggested have not been attempted on a large scale and therefore their feasibility as well as their economics remain to be worked out.

Alkali Rendering

Alkali rendering has already been discussed at some length in chapter 7. Alkali rendering has been commercially applied on a large scale for fish offals for the recovery of fish oils. Little work has been done on the feasibility of its application to carcass offal rendering.

It has been found in principle that a strong alkali like sodium hydroxide is able to liquify protein materials at room temperature if allowed sufficient time for reaction. For example, sodium hydroxide at the rate of 5 per cent by weight of offal protein could effect digestion of muscle protein in a few days time at room temperature. If the carcass material is cut into chunks and mixed with sodium hydroxide pellets (no water need be added), the whole mass liquifies and goes finally into a viscous liquid state. The liquified material obtained by alkali hydrolysis does not putrefy and stores well for as long as three months at room temperature. If an acid (hydrochloric acid) is added to this liquid slurry and stirred well to bring the final pH to between 4.5 — 5.5, a substantial amount of precipitate is obtained. The fats would have partially saponified by the action of alkali and can be recovered as an oil layer after neutralization with acid and warming to near 60°C. Thus, it becomes possible to separate proteins as a precipitate and fats as a separable layer. The precipitated protein will contain the salt of the acid and alkali used and in this case, it will be sodium chloride, the common salt.

This can be solubilized and removed by repeatedly washing the protein precipitate in water acidified to pH 4.5 to minimize loss of soluble proteins by washing. A salt content, up to a maximum of 3 per cent, can however be tolerated in the offal meal, provided care is taken not to add extra salt while preparing feed mix.

No specific data are available at present on the yields and economics of the process. It is not clear if products toxic to animals will be present in the offal meal prepared by alkali rendering (see also chapter 7). If proved viable, the method has many advantages: the energy consumed will be far less compared to heat rendering ; it provides a means to cumulate and store offals and thus be advantageous under rural conditions ; the technique is simple and does not require high level technologoy ; the fixed capital for the process is low as wooden vats serve the purpose, although recurring expenditure on alkali and acid require consideration while evaluating long range, large scale feasibility ; and when carcass material inclusive of bones are soaked, the bones easily separate. Thus, the method offers the possibility to produce offal meat meal of low ash content as bone mineral is not included.

The disadvantages could be that the yields may be low ; toxic end products may be formed ; the suitability of bones for edible end products should be considered ; (however, in processing carcasses and condemned offal material this question does not arise as bones should only be converted to bone ash or made into dicalcium phosphate and not sent to bone crushing industry for manufacture of gelatine) ; the high salt content formed may pose problems for its use in feed mix or as fertilizer ; and the quantity and quality of fat obtainable need to be ascertained.

It is possible that the use of other alkalis such as ammonia under suitable conditions (pressure) may also prove feasible.

Prussian Blue Manufacture

The offals can be used to produce Prussian blue. Prussian blue also known as the iron blue is a blue pigment—a complex ferric ferrocyanide $(Fe\ (NH_4)\ Fe\ (CN)_6)$. Prussian blue is produced from potassium ferrocyanide or sodium ferrocyanide as the starting material.

The earlier method of manufacturing the salt was by heating a mixture of nitrogenous materials such as dried blood, horns, hide trimmings and fleshings, and carcass offals with an equal weight of potassium carbonate and one third their weight of iron filings. This process has been replaced largely in the recent years by making it from spent oxide from gas works (containing cyanogen compounds), from thiocarbamide and from calcium ferrocyanide by interaction with quick lime respectively.

Potassium ferrocyanide is extensively used in dyeing and calico printing, electroplating and electroguilding, and to a small extent in photographic processes.

Potassium ferrocyanide is also the starting material for the production of Prussian blue.

From the above, it seems worthwhile to attempt the production of potassium ferrocyanide from carcass offals on a rural scale using carcass offals, horns, hoofs, feathers, putrefied or spoilt dried meat meal, hide trimmings, fleshings, etc. as raw material. The separation and purification of potassium ferrocyanide from the complex mixture of salts finally formed is however not easily achieved. Therefore, it is worthwhile attempting to produce Prussian blue which is obtainable finally as a water insoluble precipitate from the system. The precipitate of Prussian blue obtained can be decanted or filtered and dried as cakes and powdered. A scheme for its production is given below which deserves consideration.

For every 10 kg of offal material (which is 2 kg on dry weight, bones can be present and the weight should be adjusted accordingly by subtracting the approximate weight of bones), 2 kg of potassium carbonate or sodium carbonate (sodium carbonate produces sodium ferrocyanide and an inferior quality of Prussian blue pigment) and 1.4 kg of iron filings are added and the whole mass is blended well. The blended mass is heated in an iron retort to red heat and ultimately to fusion by continuing heating for an hour or more. The fused mass is cooled, crushed to a powder and dissolved in 5-8 litres of water, if necessary by boiling. The solution is filtered to remove the unreacted iron filings which can be reused. The clear filtered solution is expected to contain 400-800 g of potassium or sodium ferrocyanide depending on whether potassium or sodium carbonate was used.

Solution I

The solution of ferrocyanide salt obtained is neutralized to pH 7 or slightly acid by the drop wise addition of sulphuric acid. The pH can be checked using pH indicator paper.

Solution II

About 1500 ml water is acidified with 10-15 ml of sulphuric acid. To this, 150 g of ferrous sulphate is added and dissolved thoroughly by stirring. Any precipitate formed is filtered off.

Solution III

Sodium or potassium chlorate (about 2 g) is dissolved in about 100 ml of water.

Solution I is heated to boiling and solution II is added to it with constant stirring. A white precipitate (sometimes blue) of unoxidised pigment of Prussian blue is formed. Solution III is now added which oxidises the white pigment into the blue Prussian blue pigment. The precipitate can be allowed to settle, which it does slowly and the supernatent liquor is decanted. The Prussian blue pigment is washed free of dissolved salts either by repeated decantation or by washing in a filter. The pigment is dried and powdered in a ball mill. Steel vessels can be used for the reaction and wooden paddles for stirring. The process should theoretically yield 600-1000 g of the Prussian blue pigment starting with 10 kg of wet offal.

Among blue pigments, Prussian blue is the reddest in tint. Prussian blue is characterised by low cost, high tinting strength, fair transparency, good light fastness in mass tones and deep tints, good resistance to bronzing in dark shades, excellent bleed, bake and acid resistance. Prussian blue tends to absorb moisture and is very resistant to alkali.

Because of its good light fastness and good resistance to bronzing out at high pigmentation level, iron blue finds its major use as deep shade solid colour. It is unsuitable for light tint or high metallic shade because of less light fastness and is usually used for shading of blacks.

Potassium carbonate can be replaced with sodium carbonate for the production of Prussian blue in which case sodium ferrocyanide is formed after heating and fusion. The sodium ferrocyanide formed is then converted to potassium ferrocyanide in solution by the addition of potassium chloride. Iron turning can be replaced by precipitated iron. Precipitated iron being finely divided carries the reaction forward at a faster pace and improves yield of ferrocyanide salt.

Glycerol from crude fat

The Twitchell process for the manufacture of glycerol from low grade fats and garbage grease deserves attention. It is likely that fats produced from carcass and offal units are of very low grade and unacceptable for any industrial use and may have to be disposed as burning oil.

The Twitchell process for conversion of fats into glycerol is carried out in wooden vats by digestion with water, with as little as 0.5 per cent of Twitchell reagent at a temperature not exceeding that of exhaust steam. The fatty acids produced by the reaction can be directly reacted with alkali to produce light coloured soaps and the glycerol recovered is made available for the manufacture of dynamite grade glycerol.

In practice, the low grade fat or grease is melted and combined with an equal volume of water acidified with sulphuric acid to keep the entire reaction mixture acidic. The catalyst, namely the Twitchell reagent, (about 0.5 per cent by weight of fats) is added, stirred homogenously, and the reaction mixture heated to near boiling by blowing steam or by adapting any other method of applying heat. Heating should be continued for a few hours for the reaction to go to completion. The reaction product now contains glycerol and free fatty acids in solution. The free fatty acids are reacted by heating with caustic soda when they are converted into soaps and can be separated from the solution by pressing or filtration. The clear liquor contains 6-8 per cent glycerol. This is further concentrated to 70 per cent strength. Further concentration by open heating is undesirable and it is therefore advisable to sell the stock at this concentration of glycerol.

The Twitchell reagent or Twitchell catalysts are compounds of aromatic hydrocarbons sulphonated and coupled with a fatty acid. Sulphobenzene stearic acid and tetrabutyl naphthalene sulphonic acid are examples of the Twitchell catalyst. Naphthalene-stearosulphonic acid can be made on a small scale as follows.

One mole quantity each of naphthalene, stearic acid and sulphuric acid are reacted as follows. Stearic acid (284 g) is melted and naphthalene powder (128 g) is slowly added and dissolved. The molten solution of stearic acid and naphthalene is gently heated in an oil bath to 160°C and sulphuric acid (110 ml) is added drop wise with continuous stirring. The reaction is best carried out in a three necked flask provided with a stirring arrangement. The addition of acid should be slow taking at least one hour for the addition of 110 ml of sulphuric acid. Heating and stirring are continued for an additional two hours. The product formed is brown to black in colour and is completely soluble in water. This compound naphthalene-stearosulphonic acid can be used as the Twitchell catalyst.

The process outlined is necessarily a brief one and is intended to create an awareness rather than as a process for manufacture on a large scale.

Note : See also Acid Rendering, Appendix VI

CHAPTER—XIII

Prospects and Limitations on the Utilization of Dead Animals and Animal Offals

Size and location of units

A unit designed to render dead animal materials should receive at least 200 kg of material (equal to 2-3 carcasses) per day. Dead animals can usually be obtained to meet this need if collection and transportation systems are efficient. The centre can rely for its supplies, by collecting the required quantity from within 10-15 km radius from the unit in most parts of the country. In urban and semi-urban areas, a large number of dead calves (buffalo and cow) are available, as these are abandoned by the milkmen as parasites on their already low yielding cows.

Carcass rendering units designed to handle about 300 kg per charge can function ideally and such units can be located at distances of 25-30 km from one another. These units at times may receive a very large amount of material for processing, due to death of animals caused by disease outbreaks or natural calamities. On such occasions, running the units in three shifts pays well. The excessive material received can be transported in bulk at reasonable additional costs to the adjoining network of centers.

Cost estimates

A tentative cost estimate for a carcass rendering unit designed for low temperature (2–2.5 kg/cm^2 i.e, 30–35 psi) operation is given in Table 15.

The profit margin of 10 per cent indicated in the cost estimate is based on a stringent estimate. These rendering units can expect to receive more number of carcasses during inclement wheather. Necessity may then arise to operate even more than one shift and under these circumstances the profit margin will be far higher than that indicated. Further, the returns derived from the sale of bone ash, horns and hooves have not been included and their sales can well buffer the lean season and shut downs due to equipment failures, energy shortage and similar unanticipated exigencies.

TABLE 15

Wet rendering unit with a capacity to render 200 kg (average 2-3 animals) per day-cost estimate

1.	FIXED CAPITAL	Rs.
i.	Land and building	50,000
ii.	Boiler	10,000
iii.	Wet rendering pressure vessel (maximum capacity 300 kg per charge and maximum operating pressure 3 kg/cm^2)	10.000
iv.	Steam jacketed, press, percolating tank, drier, mill, etc.	20,000
v.	Installation costs	10,000
	Total fixed capital	1,10,000
2.	RECURRING EXPENDITURE (ANNUAL, 300 WORKING DAYS)	
i.	Cost of procuring 600-900 carcasses at Rs. 80/- per animal-average 750 carcasses (Rs. 80 × 750)	60,000
ii.	Processing costs at Rs. 15/- per carcass (Rs. 15 × 750)	11,250
iii.	Other expenses such as transportation, energy, equipment maintenance, labour costs, etc. at 15 per cent of (i) and (ii)	11,000
iv.	Interest on fixed capital (15 per cent)	15,000
		97,250
	Total recurring expense (rounded off)	1,00,000
3.	RETURNS	
i.	Return from 750 flayed hides at Rs. 50 per hide (Rs. 50 × 750)	37,500
ii.	Return from the total offal meal produced (25 per cent yield = 14 tons at Rs. 3000 per ton) (Rs. 3000 × 14)	52,000
iii.	Return from tallow (4 per cent yield = 2.5 tons at Rs. 8000 per ton) (Rs. 8000 × 2.5)	20,000
		1,09,000
	Total returns (rounded off)	1,10,000
	Percentage profit = 10 per cent	

Advantages

Carcass utilization centres where flaying followed by rendering of carcass is practised are at present managed by the Government and its affiliated agencies such as the Khȧdi and Village Industries Commission in India. Consequently, their commercial viability is not clearly apparent. Some of these operating centres bring out certain aspects that merit attention.

A carcass utilization centre

(i) provides a method to convert a waste (carcasses otherwise abandoned to rot) into useful offal meal and tallow,

(ii) offers scope for regional or local utilization of offal meal and tallow for the preparation of stock feed formulations or fertilizer and soaps respectively,

(iii) provides gainful employment,

(iv) helps to assist public health programme as dead animal matter left to putrefy could constitute fuci for causing endemics,

(v) serves as a viable rural programme.

A few of the many advantages outlined and higher margins of profit these centres can ultimately provide are worthy of attention. It is essential at this juncture to also understand certain limitations these centres impose while planning to set them.

Limitation

The rules and regulations, post-mortem inspection and certification for suitability for rendering have been outlined in earlier chapters. The present account on how these units differ from those attached to abattoirs explains certain of the limitations imposed on these units compared to the latter.

The rendering units attached to the abattoirs are called by-products utilization units and the primary equipment in operation there is a renderer. The products obtained from these units is also essentially offal meal and tallow. The tallow having been obtained from the offal of certified meat animals can be marketed as edible tallow. On no occasion, can the tallow obtained from a carcass unit be sold as edible tallow. It is for this reason that a by-product unit attached to an abattoir should and under no circumstance admit rendering of carcasses of dead animals received from outside the abattoir's jurisdiction. Food regulations all over the world forbid mixing of dead animal offals with abattoir offals into one un't for rendering. It is however possible and is permitted to take abattoir offals for processing to a unit rendering dead animal offals, but precautions for the sale of tallow recommened in chapter 6 should be strictly followed.

Future prospects

OFFAL MEAL

There has been a general opinion that the world protein supplies are dwindling at alarming rates, due largely to the increasing human population (not commensurate with rise in livestock population) and an increased awareness for better and more demanding nutritional standards. It is therefore wise and essential to devise ways and means for optimal utilization of available protein resources. The carcass materials are a valuable protein source, that can provide offal meal rich in protein for stock feed supplement. Their use in animal feed compositions certainly provides a means to replace the presently used proteinous constituents that can as well directly cater to human nutritional needs. Crudely prepared offal meals from some centres which are even unfit for stock feed are still not a waste. These can be beneficially utilized as organic fertilizer nitrogen sources. Besides serving as slow release fertilizers, they improve soil binding property and promote humus formation by supporting a rich soil microbial flora.

TALLOW

The tallows produced in carcass rendering units are unfit for human consumption. The tallows are usually of a poorer quality than that available from abattoir rendering units even for many industrial uses. The lower grade tallows can be used for the manufacture of lower grade soaps. The tallows that do not qualify for soap making due to high colour, can still serve as the starting material for the production of the Twitchell process glycerol (see chapter 12). Lower grade tallows also find market in sheet metal drawing industries where they serve as lubricants. Crude tallows can also be used as lubricating greases and as burning oils can be recycled in the rendering units to provide heat energy for boilers.

BONES

Bones are available from low temperature (2.5-3 kg/cm^2) rendering units. They are totally digested and form part of the offal meal when rendered above 4.5 kg/cm^2 (60-65 psi). The bones from rendering units recommended can be used for the production of bone ash. Bone ash can be produced in incinerators of simple and indigenous design or even fed as fuel to coal fired boilers with suitably modified furnace plates from which bone ash can be ultimately recovered. Good quality bone ash with low mud, extraneous matter and carbon content is the starting material for bone china, a ceramic of high value. Bone ash is used in mineral mixture formulations and in the manufacture of cattle lick formulations. Bones as such are used in small quantities for carving into handicrafts.

NEATS FOOT OIL

It is possible to collect the shank bones and hoofs and attempt the preparation of Neats foot stock. (Neats foot stock is the raw material that is purified to obtain the oil by complex techniques.) The yields obtainable should be critically examined before venturing production. Shank bones and hoofs from old and dehydrated animals and from animals that have been dead since long have very much lower yields of Neats foot stock than shanks and hoofs from fresh slaughtered stock.

HOOFS AND HORNS

Hoofs and horns from rendering units are sold to manufacturers of hoof and horn meal for fertilizer or for fire foam compound. A small quantity is also sold for the handicraft industry for manufacture of fancy articles. The hard 8-12 cm part on the tip of the bone has a great demand selling at as high as Rs. 10.00 per kg, four or five pieces weighing a kilogram.

AVAILABILITY OF OFFALS

The greater availability of dead animals and offals declared unfit for direct human consumption can be proclaimed to represent bad management techniques of farm livestock and abattoirs. This means that better methods to rear animals, farming and disease prevention will ultimately bring down availability of dead animals to a minimum. The concept of carcass utilization will then need a second thought. This is an utopian situation to aim for and the future for such a state will be a reflection of the greater attention paid to agriculture and animal husbandry in a country.

ABATTOIR OFFALS

The processing of abattoir offals in the by-products rendering unit should receive greater attention. Any abattoir with proper ante-mortem and post-mortem facilities can be expected to obtain offals for the rendering unit attached to the abattoir. On an average the availability of such offals is as follows :

Percentage of animals condemned ante-mortem	1-2
Percentage of whole animal carcasses condemned	1-2
Percentage of organs condemned, usually lung, liver, spleen and lumph nodes	2–10

Thus, a modern abattoir slaughtering 100 cattle, or 1000 sheep or 250-500 pigs a day can expect to obtain 100–500 kg of offal material for rendering. The availability of offals also influenced by the economic status and food habits in an area or a country. For example, in most developed countries, at least 10 per cent of the weight of carcass material is rejected as offals or as not directly suitable for table as food. These materials ideally constitute the raw stock for rendering and the tallow recovered from them is the valuable edible fat. The meat-cum-bone meal produced in these units is also of the highest quality.

RENDERING

Rendering as a technique is essentially applied for the recovery of fat from animal offals. Several advanced techniques have been developed to recover fat of highest quality. Besides the above considerations, the concept of rendering itself deserves further research from the point of view of energy inputs and optimal designs to fit into every geographical location and under-developed zones where high technology inputs are not likely to become available for many years to come.

APPENDIX—I

NITROGEN ESTIMATION BY MICRO KJELDAHL METHOD

Principle: The nitrogen containing sample is digested with sulphuric acid in the presence of small traces of copper sulphate or any other catalyst to convert the nitrogen to ammonium sulphate. Addition of 40 per cent sodium hydroxide and distilling the ammonia are done. The steam distilled ammonia is absorbed in boric acid and titrated against standard acid.

Reagents: 2 per cent boric acid, 40 per cent NaOH, Mixed (indicator prepare 1 per cent methyl red solution and 0.1 per cent bromo cressol green in 95 per cent alcohol separately; mix 10 ml of bromo cresol green with 2 ml of methyl red solution), 0.N sulphuric acid (0.0142 N), standard $(NH_4)_2SO_4$ solution (94.3 mg $(NH_4)_2SO_4$ per 100 ml water).

Procedure : Digestion of the sample: Weigh the necessary amount of the given sample in a Kjeldahl flask. Add 5 ml of conc.H_2SO_4 and boil gently with a few crystals of $CuSO_4$, on a sand bath till the solution is almost colourless. Cool and add a drop of H_2O_2 or $HClO_4$. Heat till the solution becomes completely colourless. Transfer it into a standard flask. Neutralize with sodium bicarbonate and make upto 100 ml.

Meanwhile place 5 ml of boric acid in a small conical flask. The water in the round bottomed flask of Kjeldahl's apparatus is heated and steam let out of the condenser. The outlet tube of the condenser is completely immersed in the boric acid. 5 ml of sample is pipetted out into the funnel after opening the pinch cock. This is followed by the addition of 10 ml of 40 per cent NaOH. Press the pinch cock back. Ammonia will be liberated it and escapes with the steam through the condenser into boric acid. After 15 minutes, romove the flask containing boric acid which has trapped NH_3 and add a drop of the mixture indicator. The solution is now green in colour.

A baryte burette is filled with $\underline{N}/70$ sulphuric acid. Shake well and titrate against H_2SO_4 till the green colour changes to light pink. Calculate the amount of nitrogen (1 cc of $H_2SO_4 = 0.2$ mg of N_2).

APPENDIX—II

ESTIMATION OF BIOLOGICALLY AVAILABLE LYSINE IN PROTEIN CONCENTRATES

Ground material containing 0.05 g nitrogen is dispersed in 8 ml of 10 per cent (w/v) $NaHCO_3$ in a 50 ml round bottom flask; 0.3 ml of flurodinitro benzene (FDNB) in 12 ml of ethanol is added. After 2 hours of shaking (or keeping for 24 hours), the ethanol is evaporated off over a water bath. 24 ml of hydrochloric acid (5.5N) is added and refluxed for 24 hours. The cooled contents are filtered with washings, and made up to 50 ml. 5 ml of this solution is extracted 4 times with 50 ml ether, adjusted to pH 5 with 1 ml glacial acetic acid and strong NaOH. The solution after extraction is diluted to 50 ml with water, centrifuged (if necessary) and read in the Specker absorptiometer (filter 601). Replication without FDNB gives blank. Epsilon-DNP lysine solution provides standard.

This FDNB reaction is for the practical problem of predicting 'protein quality' from the results of laboratory analysis. This method of estimating 'nutritionally available lysine' has been found to have high correlation with biological assay results (gamma = 0 97) to chick feeding. This method cannot be applied to vegetable and fermentation products without modification.

Carpenter, K. J. & Elinger, G. M., (1955), *Biochem. J.*. 61, XI, (opposite to page 528)

Carpenter, K. J., (1960) *Biochem. J.*, 77, 604.

Kakade, M. L. & Liener, I. E., (1969), Anal. Biochem., 27, 273 (This method uses 2-4-6 tri-nitro benzene sulfonic acid)

APPENDIX—III

ESTIMATION OF FAT CONTENT

A weighted quantity (10 g) of the offal meal is wrapped in a filter paper or taken in a filter thimble and extracted with a mixture of chloroform, ether (50, 50) for six hours in a Soxhlet extractor fitted with a previously weighed flask. The solvent after extraction is distilled off and the residual fat is weighed to constant weight. The content of the fat is expressed as a percentage of the weight of offal meal, preferably on a moisture free basis.

APPENDIX—IV

ESTIMATION OF ASH CONTENT

A weighed quantity (5 g) of the offal meal is taken in a previously tarred crucible. The material is gently heated to charring over a burner and then burnt directly over a blue flame taking care to prevent splashing during burning. Heating and burning are continued until no more unburnt material (black in colour) is present. Alternatively, the charred material can be ashed in a muffle furnace at 600°C for one hour. The weight of ash is determined to constant weight and the ash content expressed as a percentage of weight of offal meal, preferably on a moisture free basis.

APPENDIX—V

HIGH FREQUENCY RENDERING

High frequency rendering or microwave rendering system has a large future potential in saving energy in rendering process. The microwave technology can be understood as follows.

Electrical energy is transformed into electromagnetic energy or microwave energy by a tube called a magnetron. Essentially, this tube is like a broadcasting station sending out waves of high frequency energy into the cavity of the microwave oven. Microwaves bounce off metal surfaces much like light is reflected by a mirror so the energy beamed into the oven bounces around and is absorbed by the material to be cooked. This microwave energy agitates the molecules in the material to be cooked. The agitation produces friction which in turn generates heat. The heat generated within the material itself causes it to cook. Because all the heat is produced in the material none is wasted in pre-heating the oven and none is required to maintain oven temperature.

Microwave heating for rendering offals is soon to come on a large scale and it is likely to prove to be the most effective way of rendering. (Information Abstract from NRA).

While the above statement is ture and holds much promise, it is at present not clear if the microwave radiation that strays away from the chamber could cause any harm to workman in the vicinity. Secondly, microwave is also known to interfere with radio communication in certain frequency ranges, for example, the range used for radio astronomy.

ACID RENDERING

Acid Rendering : Rendering is also being substituted by chemical treatment of offals. One such process is to treat the animal offals with formic acid (HCOOH). The offals are ground to a fairly paste like consistency and mixed with formic acid at five per cent on the wet weight of offals. In 24 to 48 hours, a slurry is formed, which can be mixed with other dry feed stock ingredients to adjust the moisture content to 10-15 per cent in the final compounded feed mixture. This process is a low energy one as it involves no heating to remove moisture. The influence of formic acid on the nutritional quality of offal meal, the pH of feed mixture, bacteriological safety and storage capabilities remain to be investigated. (A process of this type has been worked out at pilot plant level at the Tropical Products Institute, London, England).

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